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IMMEDIATE MEMORY SPAN AND LOGICAL LEVELS

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Immediate Memory Span and Logical Levels" submitted by Richard Burns, in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

Suggested changes in curriculum often include the teaching of logic in schools. Such suggestions have lacked empirical support. The purpose of the study was to test the relationship between immediate memory and the logical level at which the child operates, and to investigate the relationship between immediate memory span and achievement scores in mathematics and science in grades three and six.

One class at each of three grade levels, grade one, grade three and grade six, from a public school in Edmonton made up the sample. Age, sex, intelligence quotients and grade levels were noted. Immediate memory spans were tested, and a Logical Levels test derived from earlier investigations was administered. The Logical Levels Test included a Conservation Sub-test, a VT (Valid-Truth) Sub-test and an IFS (Invalid, False, Symbolic) Sub-test. Grades three and six were tested for mathematics achievement using the California Achievement Test (1958), and for science achievement using the Illustrated Science Test (Reese, 1968).

Significant correlations were found between immediate memory span scores and logical levels as represented by the Conservation Sub-test, the VT Sub-test and total scores on the test.

For grades three and six significant correlations were found between immediate memory span and verbal intelligence

quotients, mathematics achievement scores and science achievement scores.

The findings indicate that immediate memory span may have significant value as one determinant of curriculum. Tasks which require a memory span greater than that possessed by a child may not be performed with logical necessity and, while verbal facility may be acquired, real understanding may not be possible. Analysis of tasks in terms of the number of units of information which must be held in immediate memory in order that the task can be performed would enable teachers to select tasks appropriate to the development of the individual child.

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CHAPTER I

I. INTRODUCTION

> Who dares to guess how our primary education would change if teachers took seriously Piaget's proposition that knowledge is an operation that constructs its objects (Furth, 1969, p. 7)?

Among changes in curriculum which seem to derive from "taking Piaget seriously" is a recurring suggestion that the teaching of logic has a place in elementary schools. The proposal has been made by individuals (Isaacs, 1960; Sanders, 1966; Buffie, 1968), by study groups and conferences (Goals for School Mathematics, 1963), and by official bodies (Program of Studies, Alberta, 1968).

The underlying reason for the suggested change seems to be that the kind of society in which we live demands reasoning ability of a high order, and that people will reason better if they are exposed to courses in logic.

Any proposal involving curriculum change should involve more than the needs of society; it should involve more than the needs of the subject structure; it should be demonstrated that the change involves activities that are within the capacity of the child. And while the suggestion that logic should be taught in elementary schools seems to have its roots in the work of Piaget, (Isaacs, 1930; Schooley, 1937), it is also clear that his evidence of the existence of stages in intellectual development, if accepted, limits the kinds of activities possible, and hence imposes limits on curriculum change.

Linked with Piaget's theory of intellectual development, but until recently (Piaget, 1968) only implicit in his account of the development of intelligence, is his theory of the development of memory.

It has been pointed out by Sanders (1966) that memory is the only mental activity fundamental to all forms of thought. And Furth (1969) translates Piaget (1968) as saying, "All intelligence partakes of memory ... (p. 160)." According to Furth, Piaget regards memory and behavioral structure as one and the same thing (p. 149).

Although he appears to offer no evidence, Piaget suggests that there is fundamentally no difference between rote memory and logical memory. As Furth (1969) says, "He puts memory ... within the totality of intellectual activity (p. 150)." He rejects a copy theory of memory; for him all memory is imbedded in intellectual structure.

Furth (1969) discusses the relation between conservation of schemes and the particular conservation of memory, and claims that for Piaget memory is "identical with the organization inherent in any scheme (p. 155)."

> As a consequence, one can expect that an act of memory will not only depend on the particular figural aspects of the given situation but will reveal the stage of the operative structure on which it equally depends (p. 157).

One measure of memory which has been extensively researched is the immediate memory span, which may be defined as the number of units of information which can be recalled following one presentation.

Miller (1956) uses the term "bits" to distinguish unrelated units of information from "chunks" which are the result of organizing bits of information into meaningful units. The immediate memory span of a new-born infant is zero. The first step in reasoning takes place when the infant learns that objects continue to exist even though they are outside his perceptual field; he then achieves a memory span of one unit. This span continues to increase throughout childhood, reaching a maximum at about the same age that Piaget suggests for the attainment of formal operations.

Piaget himself states what is essentially the problem raised in this study.

> Is memory linked, under different forms, to schemes of actions and operations? And, if so, can the influence of the schemes be observed in the memory behavior of the subject according to his operative level? (Furth, 1969, p. 158).

II. PURPOSE AND SIGNIFICANCE OF THE STUDY

The purpose of the study was to determine whether there exists a relationship between the immediate memory span of children in elementary school and the stage of logical development attained by them.

Most of the studies which have been undertaken to examine Piaget's work have replicated or extended the experiments which Piaget and his associates have devised. The possibility of checking one aspect of his theory from a completely different standpoint is suggested by Piaget's claim that memory and behavioral structure are

one and the same thing. If such a claim can be supported by empirical data, it will add to the evidence that Piaget's description of intellectual development is acceptable. If, on the other hand empirical evidence does not support the claim, this must be considered as evidence against the general theory, since Piaget regards memory as existing within the total developmental structure.

Further significance derives from the need for demonstrating that the introduction of logic into the elementary school will not make demands on the child which are beyond his intellectual capacity at that time.

Since the immediate memory span is quickly and objectively measured, it would provide an indicator of the kind of activities for which the child is ready intellectually. This would not only provide a guide to designers of curriculum, but would assist the classroom teacher in setting objectives for each child in her class.

III. THE NULL HYPOTHESES

The major hypothesis to be tested is this:

There is no relationship between immediate memory span and the logical level attained.

Minor hypotheses deriving from this may be summed up in the following:

There is no relationship between immediate memory span, intelligence, mathematics achievement and science achievement.

To test the hypotheses all pupils in one grade one class, one grade three class, and one grade six class in a school assigned

by the Edmonton Public School Board were tested using the Digit Span Test from the Wechsler Intelligence Test as an indicator of immediate memory span, and a Logical Levels Test derived from Ennis and Dieter (1965) and Hill (1960). Grades three and six students were tested for mathematics achievement using the California Achievement Test (1963 norms), and for science achievement using an illustrated test (Reese and Peckens, 1968). Intelligence scores were obtained from the class teachers' lists.

IV. DEFINITION OF TERMS

Logical level: The stage of logical thinking attained as indicated by scores on a logical levels test of five Piagetian conservation items and fifteen logical reasoning items derived from Ennis and Dieter (1965) and Hill (1960).

Immediate memory span: The average of the forward and reverse measures of immediate memory span as determined by the Digit Span Test of the Wechsler Intelligence Test (1949).

Mathematics achievement: The scores on the two parts of the California Achievement Test: Arithmetic (1957). One score indicates knowledge of notation and problem solving, the other indicates mastery of fundamental operations.

Science achievement: The score on the Illustrated Science Test (Reese and Peckens, 1968).

Intelligence: The scores -- one classified as 'Non-verbal' and one classified 'Verbal' -- obtained on the Lorge-Thorndike Test of Intelligence for grades three and six; and the score on the Detroit Beginning Grade One Intelligence Test for grade one.

V. LIMITATIONS

In interpreting the results of the study the following limitations should be borne in mind:

(1) The sample used is from one school in the Edmonton public school system.

(2) Only one class at each of the three grade levels was used.

(3) No attempt was made to assess the school experiences, or any other experiences to which the children may have been exposed.

(4) It was assumed that any effect of such experiences, or due to socio-economic status, or any other variables would be one-way, i.e. such variables would have affected the variables in the study in the same direction.

(5) It was assumed that the Logical Levels test did in fact measure differences in reasoning development. No measure of validity was obtained.

(6) The total number of students involved in the study was 84.

VI. OUTLINE

In the chapters which follow, the literature related to the study is reviewed in Chapter II, the design of the study is presented in Chapter III, the results are analyzed in Chapter IV, and the conclusions and implications of the study are presented in Chapter V.

CHAPTER II

A review of the literature related to the introduction of logic into the schools, and the literature related to three of Piaget's major themes; intelligence, memory, and the relationship of biology to memory and intelligence are presented in this chapter. A summary of studies on which the testing instrument was based is then provided.

I. LOGIC IN THE CURRICULUM

Isaacs (1960) argues that a very strong case can be made for the teaching of logic in schools. He points out that "number is a synthesis or fusion of the two basic processes that underlie logic, classification and seriation" (p. 30), and goes on to wonder why logic is not recognized as being as basic and necessary a part of every education as arithmetic is.

Sanders (1966) observes that "very little formal logic finds its way into the curriculum" and agrees with Isaacs that this is a deficiency, since "reasoning is among the most important goals in education (p. 10)."

Buffie (1968) adds force to the argument. He too, sees rational power as the focal point of education, and elaborates the point.

> Nowhere is it better served than when pupils attempt to apply human reason to problem situations. Logical reasoning enables pupils to extend belief to fact (p. 52).

The authors of the report on the Cambridge Conference on School Mathematics (Goals for School Mathematics, 1963) agree with this point of view.

> Just a little experience with logic and inference can do away with some of the unfortunate reasoning we meet all too often (p. 9).

The Program of Studies for Elementary Schools (1969) emphasizes in several subject areas the importance attached to logical thinking, and in listing the desired goals in these areas refers to process skills such as classifying, inferring, problem solving, hypothesizing, and critical thinking.

Some recent mathematics programs for elementary schools (Keedy, 1968) include sections which the authors suggest will develop logical thinking, others (Morton, 1970) include lessons in formal logic.

Although the proposal for teaching logic in schools receives fairly wide support, even the supporters are among those who point out that there is very little known about the probable outcome of implementing such a proposal.

The authors of Goals for School Mathematics (1963) concede that "At the elementary school level, the amount of logical or inductive reasoning that will be appreciated is uncertain (p. 10)."

Miller (1955), while claiming that the desirability of teaching for improvement in the ability to reason critically has long been a subject of agreement among educators, concludes that teachers who have attempted to do something about it have given up

because, "the initial activities in this area may have been on too difficult a level for the students involved (p. 128)."

Isaacs (1960) points out that for the ability to handle logical relationships with the same freedom with which we handle simple numerical ones, "we must wait in the case of most average children, till they have reached the age of 11 - 14 years (p. 32)."

Curriculum reform based on such conflicting evidence is no more than guesswork. Cronbach, in Ripple (1964), suggests that learning theories have not been particularly helpful in telling the curriculum makers how to arrange an optimum sequence of experiences for children in school, and finds that Piaget's theory of cognitive development poses similar questions with regard to bridging the gap between cognitive development and curriculum development (p. 77). Although he finds the pedagogical bridge obscure, he does see the possibility of relating Piaget's cognitive theory to the concern of the curriculum maker by means of the type of instruction that develops mental structures and facilitates the assimilation of new and different material.

The implications of Cronbach's remarks seem to be two-fold. There is a need to demonstrate beyond any possible doubt that Piaget's theory of cognitive development is a true description of intellectual growth; and there is a need to spell out in detail the kinds of activities that are possible at each stage of development.

In the next section, Piaget's theory is discussed, and selected research on various aspects of the theory is evaluated.

II. PIAGET'S THEORY

An examination of Piaget's (1950) description of the development of intelligence, and his description of the development of logical thinking (Piaget, 1957; Piaget, 1958) reveals that, for him, intelligence, cognition, and logical thinking are synonymous.

> Intelligence is then only a generic term to indicate the superior forms of organization or equilibrium of cognitive structurings (Piaget, 1950, p. 7).

He maintains that behavior at all levels shows some aspect of structuring, and he identifies structuring with knowing.

The development of cognitive structures is seen by Piaget as proceeding by stages. By stages he means the relatively stable structures of knowing which characterize the behavior of the organism. Other authors from Freud on have used the idea of stages or levels in descriptive psychology but none has offered such a detailed step-by-step description of intellectual development as Piaget has. Sigel (1968) believes that, "The centrality of the stage construct, as well as the specificity of the stages, is a significant contribution of Piagetian theory to developmental psychology (p. 2)."

The criteria of the stages have been summarized by Inhelder (1962) as follows:

> 1. Each stage involves a period of formation (genesis) and a period of attainment. Attainment is characterized by the progressive organization of a composite structure of mental operations.
> 2. Each structure constitutes at the same time the attainment of one stage and the starting point of the next stage, a new evolutionary process.

> 3. The order of succession of the stages is constant. Ages of attainment can vary within certain limits as a function of factors of motivation, exercise, cultural milieu and so on.
> 4. The transition from an earlier to a later stage follows a law of implication analogous to the process of integration, preceding structures becoming a part of later structures (p. 23).

There are four stages, though some writers include the second as part of the third. The labels used by Piaget, the approximate ages at which the stages occur, and a brief statement of the chief characteristics of the stage follow:

Stage 1. Sensori-motor: from birth to about age one-and-a-half years; characterized by the progressive formation of the permanence of objects and the structuring of one's immediate spatial surroundings.

Stage 2. Pre-operational: from age one-and-a-half to seven years; characterized by the gradual construction of two forms of reversibility; negation and reciprocity. Until these are available as thought operations there is a lack of the principle of invariance or conservation.

Stage 3. Concrete operations: from age seven to eleven or twelve; characterized by the principle of conservation, which is extended from number to length, quantity, weight, etc.

Stage 4. Formal operations: from age eleven to twelve becoming relatively stable at fourteen to fifteen years; characterized by the ability to reason hypothetically; thought is no longer tied to the concrete data from which it derives.

There are four factors, according to Piaget, which produce

this development through the stages. They are: maturation, which implies an increasingly specialized and complex differentiation of the physical bases of thought in the nervous system; experience, particulary with the physical world, provides the encounters and activities necessary for intellectual growth; social transmission, which parallels experience, but is composed of encounters with human beings, especially those concerned with education; and, most important of all for Piaget, equilibration, the tendency of the organism to maintain equilibrium between itself and the environment. The individual adapts himself to the world, and the world to himself by twin processes of accommodation and assimilation. Assimilation expresses an inner correspondence between an environmental phenomenon and the structures within the organism. Accommodation is the process whereby existing structures are adapted to a particular situation. In a restricted sense, accommodation to a new situation leads to the differentiation of a previous structure and thus the emergence of new structures.

The equilibration factor is the distinctively Piagetian postulate in this process of development. The idea of stages seems to imply plateaus or levelling off of periods in child development, an idea with which many psychologists disagree. However, as Ginsburg (1969) points out, "equilibrium does not have the connotation of a static state of repose between a closed system and its environment (p. 172)." The system is an open one and, as Wallace (1965) stresses,

> ... the development of the intellectual processes,

> however, through the stages, ... makes it possible for equilibrium to continue as the environment becomes increasingly complex. (It) is not a static, but an active system of compensation (pp. 56-57).

The theory rests on the idea of operations which Piaget (1957) defines as follows:

> Psychologically, operations are actions which are internalizable, reversible, and co-ordinated into systems characterized by laws which apply to the system as a whole (p. 8).

Operations are actions because they must first be carried out on objects before they can be carried out on symbols; they are internalizable because the original action is not lost when the operations are carried out in thought; they are reversible as contrasted with simple actions which are irreversible -- when a slice is cut from a loaf it remains cut, but an operation, a mental action, can restore the slice to the loaf -- and, finally, operations are systems because they require the integration of concepts and relations between concepts into structured wholes. The number system structure, for example, requires operations leading to classification (combining on the basis of likeness) and seriation (ordering on the basis of difference) and the structuring into a whole of the operations involved.

"The criterion for the appearance of such operational systems is the construction of invariants or concepts of conservation (Piaget, 1957, p. 8)."

The first of these invariants is the permanence of objects.

The object is permanent in the sense that its continuing existence is recognized even though the object is outside the child's perceptual field. The child remembers the object. At this, the lowest level of thought, memory is involved, and the child acquires an immediate memory span of one unit. Piaget (1957) explains it in this way:

> The object's permanent character results from the organization of the spatial field, which is brought about by the co-ordination of the child's movements. These co-ordinations presuppose that the child is able to return to the starting point (reversibility) and to change the direction of his movements (associativity), ... and thus even at the sensori-motor stage one observes the dual tendency of intelligence towards reversibility and conservation (p. 9).

Once this invariant appears, the way is open for symbolic functions to appear. First among these is the classification of objects which starts with the appearance of language; the child gains a means of classifying when he is able to name an object. The child is now in the pre-operational stage. During this stage internalization of actions becomes possible as the symbolic functions of language, imitation, symbolic play, and mental imagery appear. It is late in this stage that a child is able to carry out an action in thought; he tends, instead, to perform the action.

There is only a tendency towards reversibility during the pre-operational stage, and hence an absence of conservation on any level higher than the sensori-motor. Perceptions dominate, and perceptual distortions seem to the child to change the material content of the object, in terms of length, or amount, or weight, or any other

measurable content.

Originally Piaget called this the pre-logical stage but Isaacs (1930) pointed out that she had observed causal reasoning in children at this level. Piaget accepted this, and qualified his original statement by suggesting that logic be considered as being based on operations. To avoid the criticism he then re-labelled the stage as pre-operational.

As the child's thought activities acquire reversibility, he enters into the concrete operations stage. The name is suggested by the fact that the child is dealing with operations carried out on the objects themselves, although physical manipulation is not necessarily implied, but the child cannot yet separate his thoughts from the concrete data from which they derive and to which they apply. Reversibility does, however, constitute a logical gain, for now, when a class of objects is divided into sub-classes, the class is not destroyed by the perception of sub-classes. Operational thought enables the child to conserve the class mentally while dealing with the sub-classes which may constitute it. Piaget (1957) concludes, "Conservation has thus to be conceived as the resultant of operational reversibility (p. 8)."

A further logical gain which develops during the concrete operations stage is that of seriation. When a very small child is presented with a number of sticks of different lengths, his attempts at ordering them are confined to selecting which is the longer of any

two of them. The idea implied by seriation is that if A is greater than B and B is greater then C, then A is greater than C. Conservation of number requires both seriation and reversibility, and it is early in the concrete operations stage that conservation of number is achieved.

Piaget (1959) sums up the main characteristics of the concrete operations stage in these words:

> Childish reasoning between the years of 7 - 8 and 11 - 12 will therefore present a very definite feature, ... reasoning that is connected with actual belief, or in other words, that is grounded on direct observation, will be possible. But formal reasoning will not yet be possible. For formal reasoning connects assumptions, ... propositions, that is, in which one does not necessarily believe (pp. 250-251).

The fourth stage, formal operations, is, as the above quotation suggests, characterized by the ability to reason by hypothesis. There is a willingness to accept data regardless of their concreteness or truth. As Flavell (1963) puts it:

> The most important general property of formal operational thought, the one from which Piaget derives all the others ...., concerns the <u>real</u> versus the <u>possible</u> (p. 204).

Piaget (1950) describes the stage in terms that would generally be considered as characteristic of formal logic,

> Formal operations therefore, consist essentially of implications ... and contradictions established between propositions which themselves express classifications, seriations, etc. (p. 149).

Piaget emphasizes that the attainment of formal operations is not the result of a growing linguistic ability. It is not an increasing facility with words to express concepts already formed. The formal operations stage is distinguished by the development of the logic of operations.

Although Piaget's theory derives from thousands of observations over many years, his work has been criticized on methodological grounds by many psychologists. The main criticisms may be summarized as criticism of his procedures which were not standardized; criticism of the samples which were cross sections but from which he derived a theory of longitudinal development; and criticism of the verbal methods he uses, and from which he deduces the existence of structures which he himself declares are not dependent on verbal ability. Some criticism (Estes, 1956) has apparently been based on misunderstandings which have subsequently been clarified; others have led Piaget to modify aspects of his theory or his methods. In any case, a survey of some of the research based on his theory is necessary before an idea of the general acceptability of the theory may be gained.

Williams (1958) constructed a battery of tests derived from Piaget to test children's understandings of conservation, and, in addition, tested their arithmetic attainment. The results demonstrated that children can reach a deceptively high standard when performing mechanical arithmetic, yet lack understanding of the nature of number relationships. Rapaport (1958) also concluded that computation was a poor indicator of understanding.

Mannix (1960) tested 48 educationally sub-normal children, using Piaget's tests, but with a degree of standardization, and concluded that the answers oscillated between pre-operational and operational levels in much the same way as those of Piaget's subjects. The results suggested that the understanding of number is a single progression.

Beard (1961) confirmed this progression with a sample of over 300 children, and reported that the order of difficulty followed closely the order found by Piaget; matching, counting, relating series and performing simple operations with numbers.

Dodwell (1960, 1961) devised a standardized test of number consisting of five different types of test material. Two hundred fifty subjects ranging in age from five years one month to ten years one month were tested. Although answers corresponding to each of Piaget's stages could be discerned, it was difficult to decide overall whether a child was in one stage or another. Dodwell feels that this does not refute the stage concept, but that it does suggest that a child can be at one stage when dealing with one type of material without being able to deal consistently with other types of materials or other apparently similar situations.

Lovell (1961,a) had raised a similar question. He suggested that once the logical concepts of inverse operation and compensation of parts were attained they should be generally applicable. However Piaget (1951) makes clear that a concrete operation is not

generalizable until the operations are co-ordinated into a system.

Wohlwill (1960) introduced a non-verbal technique based on stimulus-response-reinforcement experiments. He concluded that the findings justified the suggestion that a consistent developmental process was operating in the conceptualization of number. In the final discussion he considered the origin and determinants of the observed developmental sequence. Having for reasons suggested by the analysis of the data, rejected maturation, language, and school experiences, he attributes the development to cumulative learning effects of a non-specific type. This could easily be translated into the factor of equilibration suggested by Piaget.

Wohlwill and Lowe (1962) raised the possibility that non-verbal tests require an understanding of the fact that absolute number remains unchanged, while verbal tests require application of this understanding. Greco (1962) obtained clear evidence of this, and distinguished these by using the terms absolute conservation and relative conservation. In subsequent studies involving verbal and non-verbal tests this possibility should not be ignored.

Braine examined the ontogeny of logical operations in connection with conservation of length by non-verbal methods. He claimed that the confounding effects of vocabulary development cannot be eliminated unless non-verbal methods are used. He suggested that Piaget's methods account for the belief that the concrete operations stage emerges at about seven years. He himself

found evidence that the period of transition from the pre-operational stage occurs during the pre-school years rather than at age seven years. He did add, however, that the data in his study provided considerable support for Piaget's notion of emergent levels and for his conception of the emergent processes as operational thinking.

Over the following years a controversy developed between Braine (1964) and Smedslund (1963, 1965), which emphasized the basic difference between their psychological positions. For Braine a non-verbal response is itself indicative, for Smedslund a response is always followed by the question "Why?", and Braine insists that the concept does not require in addition the language facility that this demands. Although this may be interpreted as being a difference of opinion concerning the ages at which a stage emerges, there is, implied at least, a disagreement about the nature of the processes which underlie the concepts with which Piaget's theory deals. There is considerable difficulty in devising tests which will yield acceptable results because of this disagreement concerning the necessary conditions for conservation.

Lovell, Healey and Rowland (1962) comment on the verbal facade which some children possess while lacking the operational mobility to understand what they are doing. They conclude that the main stages proposed by Piaget are confirmed by their study.

It has been pointed out (p. 9) that for Piaget intelligence and logical thinking are synonymous. Studies which have concentrated

on tasks involving direct application of logical thinking are now reviewed.

Lovell (1961,b) confirmed the main stages in the development of logical thinking proposed by Piaget and Inhelder. They seemed to be correct in suggesting that rarely did elementary school children reach the stage of formal thinking. Lovell pointed out that maturation is likely to fix a lower limit, different for each child, below which certain thinking skills are not available to him.

Lodwick (1959) asked his subjects questions involving inferential judgements on passages with historical content. He supports Piaget's account of the development of logical thinking, and infers that the study of history as a causal pattern can have little meaning for elementary school children.

Case and Collinson (1962) in a similar study, extended to include questions involving inferential judgements on passages with geographical and literary content, indicated that Piaget's theory of the structure of thought was confirmed by their study. They stressed the necessity of the earlier stages for the attainment of formal thought, a point which supports the integration analogy referred to by Inhelder (1962).

Lovell, Mitchell, and Everett (1962) used a series of tests on classification, and included educationally sub-normal children in their study. They reported that their results agreed fairly well with those of Piaget and Inhelder, and pointed out that

educationally sub-normal children, while developing the earlier stages in the same sequence, have limited ability to develop logical structure.

Shantz (1967), in a study based on Piaget's theory of logical multiplication, found only moderate support for Piaget's hypothesis that a close relationship exists among multiplicative abilities, which underlie conservation concepts.

Kofsky (1966) constructed eleven tests, based on Inhelder and Piaget (1964) to determine whether the order of difficulty of classification tasks corresponds to that described by Piaget, and whether mastery of a particular classification rule reflects mastery of previous rules. She found that the observed order of task difficulty was in accord with theoretical expectations. The scalogram analysis which she used indicated, however, that the invariance of the task mastery sequence was not substantiated. She concluded that "A better way of describing individual growth sequences might employ probability statements about the likelihood of mastering one task once another skill has been or is in the process of being mastered (p. 203)."

Laurendeau and Pinard (1962) in a longitudinal study of casual thinking used subjects in Montreal, and repeated their study in Martinique. They found support for Piaget's formulation of development by stages, though the children in Martinique were up to four years later than their Canadian counterparts in achieving a particular stage.

Smedslund (1964) reported that children tended to pass both class and relational multiplicative tasks or to fail both. The study seems to be the only empirical support for Piaget's hypothesis that there is a close relationship among the three multiplicative abilities; the multiplication of classes, logical relations, and spatial relations. These abilities are significant in Piaget's theory of logical development, and the results of Smedslund's study must be considered in the perspective of Shantz (1967), who found only moderate support for Piaget's theory. The total impact of the two studies is to raise methodological questions. When spatial dimensions are elements of a study which examines a cognitive matrix, there is bound to be some degree of doubt as to whether or not a logical relationship is being measured. On the other hand, attempts to verify Piaget's theory by verbal methods run into the kind of criticism which Braine (1959) makes.

The point of view taken in this study will be that expressed by Inhelder (1962) in commenting on research involving standardization of some of the procedures used by the Geneva school and a hierarchical analysis by means of ordinal scales. "It is noteworthy and reassuring that this hierarchical and statistical analysis lends broad confirmation to the succession of stages of reasoning (p. 22)."

III. MEMORY

"Every conceivable aspect of learning could be theoretically explained as a direct effect of memory (Furth, 1969, p. 148)."

Furth examines Piaget (1968) and translates excerpts from the manuscript. The section which follows is derived entirely from Furth (1969) and, apart from the translations, may be regarded as one interpretation of Piaget's views on memory and intelligence.

Piaget, according to Furth, contends that a memory image is no more than a symbolic manifestation of a whole series of knowing structures. The memory image is thus dependent on knowing structures. The knowledge that London is the capital of England may be accompanied by no visual image, and while the image may be dispensable for memory, knowing must always be there.

Piaget reports an experiment which confirms this. Children of six or seven were presented with a drawing of a wine decanter half full of wine and tilted to one side. This would be a familiar item to children in Geneva, but is one which children up to eight or nine years of age rarely are able to draw correctly. The children recognized the drawing for what it was and were able to copy the drawing correctly. An hour later they were asked to draw it from memory. Most of them succeeded. A week later they again drew it from memory, but now the oblique levels of liquid characteristic of young children's drawings appeared. It seemed that the figurative knowledge had given way to the operative knowledge, what they had actually comprehended when seeing the drawing. Other tasks involving seriation showed the same thing, but after six months an improvement was noted, suggesting that as the operative knowledge of the children improved so did their memory.

Piaget distinguishes three types of memory; recognition, reconstruction, and evocation. He assigns different bases for these; perceptual for recognition, imitative for reconstruction, and imaginal or linguistic for evocative. Piaget then asks how the three levels of memory -- recognition, reconstruction, and evocation -- fit in with the developmental stages (Furth, 1969, p. 161).

What seems to be implied here is the general observation that even the rote memory of nonsense is improved by applying some organizing principle, rhythm or rhyme or association. From this point Piaget seeks some generalizing principle that will account for the diversity of memory. He finds in the general presence of schemes of memory and a similar successive order of memory types, arguments in favor of a general unity of functioning.

> Thus, in the final analysis, there is no essential difference between rote memory and logical memory; in fact, logical memory provides evidence for the indissociable general relation between memory and intelligence (p. 163).

This 'indissociable general relation' seems to have its basis in biology. Furth (1969) has also translated and commented on sections of Piaget (1967). He comments that Piaget sees a biological organization as an open system subject to the vicissitudes of its environment. External behavior extends the organism into the environment and at the same time tends to close the system in order to conserve the organization of the organism. This double function is only partially fulfilled by external behavior. Knowing is a

further evolutionary step which can attain the double function more completely. It can extend itself into an indefinite variety of situations in all thinkable ways and yet conserve the stability of its structure through complete compensation.

In his search for truth, Piaget looks into the biological organization. An organism acquires knowledge either by evolutionary means through the species or developmentally through the individual. The knowledge acquired in the course of evolution can be called biological memory or memory of the genes.

The point raised here has stimulated research in other disciplines which may have relevance to the relationship Piaget seeks between biology and cognition. Cognitive psychologists often concede the possibility that neurophysiological processes accompany and make possible certain cognitive events, but claim that these take place at a substrate level that has no explanatory value for these events. As Ausubel (1963) says,

> ... correlates undoubtedly exist for the raw material (percepts and images) but ... the combination of and interaction between images and percepts involved in problem solving, concept formation, and thinking probably have no neural concomitants (p. 7).

Werner and Kaplan (1963) point out that "it is the milieu impinging upon the organism that affects its behavior in the form of physico-chemical stimuli," though they immediately qualify this as taking place only at earlier phylogenetic levels. They do not make clear why this should be so, and are content to say that at

the human level the environment is "cognized," which seems to have less explanatory value than substrate events.

As Pribram (1964) points out, "A return to neurophysiological fundamentals can clarify issues, and, on occasion, resolve them (p. 79)."

Wallace (1965) suggests that the conclusion is inescapable that only when neurophysiological research provides a reliable description of the neural bases of conceptual behavior, shall we have certainty regarding the identity of hypothetical constructs and psychological processes.

Thompson (1969) declares that:

> The chief way that a nerve cell can influence other nerve cells is by synaptic actions, and ... it has been demonstrated beyond reasonable doubt that synaptic transmission in the mammalian CNS is <u>chemical</u> (pp. 42, 43).

Lawson (1967) proposes a neurophysiological theory of learning in which he assumes the existence of a chemical memory record or code within the brain stem.

What is this chemical record? Returning to the idea that evolutionary knowledge is transmitted by the genes, and the discovery of deoxyribonucleic acid (DNA) as the fundamental chemical involved in gene structure, it is natural to seek the answer in this substance or related substances.

Cameron (1965) reported experiments on humans involving

ribonucleic acid administered orally and intravenously. The elderly people involved began to demonstrate definite but limited improvement in memory deficits.

Cameron cites McConnell, Jacobson, and Kimble (1959) and Corning and John (1960), who experimented with the effects of ribonuclease upon planarian regeneration. Ribonuclease has the effect of breaking down RNA. Planarians trained to run a simple maze were transected and allowed to regenerate. Those which regenerated in pond water showed a capacity to run the maze; those which regenerated in ribonuclease performed only randomly.

Cook (1965) reported that rats chronically treated with yeast RNA show an enhanced acquisition of a behavioral response motivated by shock, and a greater resistance to extinction of the response than do rats not so treated.

Hyden and Pigon (1960) reported that ribonucleic acid concentrations rise in neurons during activity and perhaps during learning, and after such activities a decreased amount of RNA is found in the neurons, but an increased amount is found in the glial cells surrounding the neurons.

Pribram (1964) points out that nerve cells secrete a greater amount of RNA than any other cells in the body. He points to the close chemical relationship between RNA and DNA, which is the material from which genetic memory is formed.

These studies appear to have had very little impact on the

psychology of cognition, even though they are consistent with the views held by many cognitive psychologists. The labelling of such phenomena as substrate and therefore as having no explanatory value seems to do an injustice to the facts.

Piaget's insistence on the identity of memory with behavioral structures, his whole theory of the development of intelligence, his factor of equilibration, adaptation as twin processes of assimilation and accommodation, are all consonant with the neurophysiological research cited above. Furth (1969) comments that Piaget sees, quite late in evolutionary history, the emergence of a new type of knowing, as the mechanisms of instinctual behavior finally burst (p. 198). This, too, can be conceived of as the result of the emergence of new chemical combinations perhaps resulting from increasing interaction between the individual and the environment. That the inheritance of organisms, or at least some organisms, has increased is indisputable. A human infant today surely has a greater genetic knowledge than his primitive ancestors. Whether the acquisition is accidental or not in the first place is not relevant; genetic inheritance has changed. Genes are mechanisms for the transmission of acquired characteristics; it seems more parsimonious to theorize that inherited knowledge and developmental knowledge have the same basis.

It should be made clear that these speculations are not Piaget's. In reviewing the literature related to memory, they have intruded of necessity. One cannot view studies on memory in a

vacuum; frequent references, even disparaging reference, to neurophysiology force some consideration of the contributions, actual or potential, of this science, and force the conclusion that perhaps, as Piaget (1967) says, "an interdisciplinary effort ... is still much too infrequent for the problems at hand (Furth, 1969, p. 202)."

Returning to the point that Piaget has made, that rote memory and logical memory are identical, there opens up a field of research in which the findings are very precise, although the significance of these findings is not always so precise.

Miller (1966) raises essentially the same problem as this study, the relationship between memory and the ability to reason.

> The intimate relation between memory and the ability to reason is demonstrated every time we fail to solve a problem because we fail to recall the necessary information (p. 161).

He suggests that the first person to propose an experimental test of the span of a man's instantaneous grasp seems to have been Sir William Hamilton, a 19th century Scottish metaphysician. Hamilton used marbles to establish that six or at most seven items could be recognized numerically from an exposure which was too short to permit counting. Miller points out that this is essentially a perceptual task and that it would be better, if we wish to test apprehension, to ask for the recall of various symbols in a given sequence.

Such studies have, in fact, been undertaken from 1887 to the present. Munn (1954) cites a long list of studies measuring recall of items including digits, letters, syllables, words, drawings, loudness of sounds, musical tones, etc.

Keppel (1968) observed that "the span of immediate memory in man is severely limited (p. 169)." There appears to be some variation in the immediate memory span depending on the particular item used in testing. Kaufman (1949) investigated the ability to identify random patterns of dots flashed on a screen -- a modern version of Hamilton's marbles test -- and found that subjects made no mistakes with up to five or six dots. Garner (1953) found about five as the limit when loudness of sound is used, and Pollack (1952) found six as the upper limit for musical tones.

Many of the studies cited by Munn (1954) make it clear that the immediate memory span gradually increases from infancy to a maximum in adolescence. Munn (1955) refers to a study by Starr in 1923 in which the auditory-vocal memory span of 2000 children from four to fifteen years of age was measured. Starr reported spans of four digits at four to five years, five digits at six to eight years, six digits at nine to twelve years, and seven digits beyond this age.

The Wechsler Intelligence Scales for Children (Manual, 1949) gives approximately the same figures: two digits at about two and a half years, four digits at about four and a half, and seven digits by about thirteen and a half.

It is clear from the literature on immediate memory span that there is an increase in the span which develops during the same years that the growth of intelligence is taking place. McLaughlin (1963) makes the parallel even more specific. He points out that each of the stages in Piaget's theory of development of logical ability requires a logic which is expressible in terms of the logic of classes. Each stage in Piaget's theory can be defined by the number of different classes that must be distinguished simultaneously. "Furthermore this number can be directly identified with a clearly measurable psychological characteristic -- memory span (p. 61)."

By way of explanation, McLaughlin points out that making a deduction involves the problem of determining whether the presence or absence of certain properties enables us to place an object in a given class. If the properties which enable us to distinguish a particular class are 'n' in number, then finding a solution to the problem may involve the consideration of 2^n possibilities. Thus the value of 'n' specifies a unique logic.

It is clear that the relevant properties must be in immediate memory while a solution is being sought, and hence the immediate memory span will place an upward limit on the logical stage that can be achieved.

If this position is accepted, then the sensori-motor stage is the stage corresponding to an immediate memory span of one digit; the pre-operational stage is the stage corresponding to an immediate

memory span of two digits; concrete operations will require an immediate memory span of four digits, and formal operations will require an immediate memory span of eight digits.

If there existed a test which was regarded as a true test of logical level this hypothesis is clearly testable. The difficulty, as the literature already cited indicates, is one of agreement on two very fundamental things; what logical thinking is and what evidences it. As Long (1941) so aptly said, "In a study of the development of the ability to reason, the problem of definition is encountered immediately (p. 21)."

Some researchers have reported on the kinds of logical thinking available at different age levels, and while they, too, have had their difficulties with definition, the work of Hill (1960), Suppes (1965), Janis and Frick (1943), and Schooley and Hartmann (1937) offers valuable guidelines to the investigation of the hypothesis implied by McLaughlin's formulation cited above.

Schooley and Hartmann (1937) had claimed that:

> Learning standard logical relationships is not a slow gradual process involving practice-effect or trial-and-error responses but occurs suddenly and gives evidence of permanent mastery (p. 291).

This is certainly suggestive of a <u>stage</u> type of development.

Hill (1960) argues in a discussion of problem solving,

> This suggested relation between logically correct thinking and problem-solving processes heavily

> underscores the importance of extending the existing body of evidence pertaining to children's abilities in deduction, for problem solving is a crucial concern in the fields of psychology and education (p. 7).

And a little later

> ... evidence concerning children's acquisition of particular patterns of thought has implications for both methodology and curricular sequence in the teaching of mathematics (p. 10).

Her study aimed at measuring the ability of six, seven, and eight year old children to derive logical inferences from sets of verbal premises which represented hypothetical situations. She concluded that there is an association of logical ability with age differences. She reports that her subjects achieved considerable success with a high percentage of the questions.

Suppes (1965) concluded that children above the upper quartile of mathematical ability in grades five and six can attain a level of mastery of mathematical logic 85 to 90% of that achieved by comparable university students. It is difficult to reconcile these results with those reported by Hill, cited above. Hill was measuring what had been achieved by operation of the factors characterized by Piaget as maturation, experience, and equilibration, and Suppes was involved with teaching elements of formal logic. It seems remarkable that Hill should find a natural achievement among six, seven, and eight year olds, while Suppes could only achieve success with mathematics achievers above the upper quartile in grades five and six.

Janis and Frick (1943) may have touched on the reason for this apparent contradiction. They noted that there are more errors in judgement of logical validity in two situations. If a valid argument leads to a conclusion which contradicts the experience or the belief of the subjects, or if an invalid argument leads to a conclusion with which the subjects' experience or belief agree, then they are liable to make mistakes. This would seem to suggest that the ability to judge logical validity is only attained when the subject's opinion or belief with regard to the conclusion does not interfere with the ability.

It is undoubtedly possible to be deceived by a child's response to a question such as: All the boys are in that room; Timmy is a boy. Is he in that room? The child has direct experience of the situation, and is quite likely to answer, "Yes" without considering any other possibility. As his experience is extended he learns that the obvious is not always the correct solution, and starts to consider other possibilities. During the concrete operations stage, it is conceivable that he will answer correctly questions if the correct answer reflects his experience, and he will be likely to answer incorrectly those items which have a conclusion which contradicts his experience. It is, perhaps, because the majority of the items on Hill's test reflected the child's increasing experience that she was able to discover a relationship between age and success on her test instrument.

Ennis and Dieter's (1965) study was similar to Hill's.

The range of items was broader, and the age range of the subjects included all those in school. Major advances in capacity for mastery of the principles of ordinal logic occurred in the six to twelve year old group. The items in the test instrument included symbolic items such as, "If X is greater then Y, and Y is greater than Z, then X is greater then Z," and items using nonsense words such as, "If a mef is faster than a nar, and a nar is slower than a tud, then a tud is the slowest of all three." Items such as these offered the most difficulty to elementary school children.

In attempting to ascertain the attainment of formal operations this last observation is important. As Piaget (1950) points out, at the level of formal thought "the subject becomes capable of reasoning in a hypothetico-deductive manner (p. 148)." Flavell (1963) makes the point that "it is the ability to deal with the possible rather than just the real, that supposedly is uniquely found in the formal operational period (p. 204)." Hence the difficulties experienced by children in Hill's study and Ennis's study may well be evidence that the formal operations stage has not been achieved.

SUMMARY

A review of the literature which supports the idea that logic should be introduced as a subject in the elementary school has been presented. The overall impression gained from this literature is that the suggestion is made from a position of need rather than research. It is suggested that curriculum reform

should be based on the demonstrated capacity of the child rather than the needs of society.

A major theory dealing with the development of intelligence has been presented, together with some of the research that it has stimulated. The stage theory of Piaget seems to offer a model for curriculum development, in that the characteristics of the stages are known, and the sequence of the stages is known. The research based on the theory is not by any means unanimous, but there is a considerable amount of empirical support for the broad sequence of the stages. Some of the biological questions raised by the theory itself, and by neurophysiological research were examined, and although no firm conclusions can be drawn, there exists a need, which Piaget emphasizes, for interdisciplinary approaches to learning theory.

A brief survey of the research related to immediate memory span was presented, the conclusions from which are unequivocal. Immediate memory span in man is limited; it is in the range seven, plus or minus two; and it increases from birth to adolescence.

Immediate memory span and logical development may be linked; Piaget declares that there is no difference between logical memory and rote memory. Rote memory may be measured by the immediate memory span.

The literature almost compels the hypothesis that there is a relationship between memory and cognitive structure.

CHAPTER III

THE EXPERIMENTAL DESIGN

A brief explanation of the sample, a description of the test instruments, the scoring, and the procedures used to analyze the data obtained in the study are presented in this chapter.

I. THE NATURE OF THE SAMPLE

Two possibilities for obtaining the sample were available. A small number of children at each of the grade levels in elementary schools across the city could be tested. In such a sample one would expect randomization to take care of such variables as socio-economic status, and any cultural effects which might be attributed to it, ethnic origin, and any effect attributable to it, school facilities, quality of staff, and any other factors which might conceivably have an effect on the variables involved in the study.

This method was rejected for two reasons. Edmonton is a comparatively small metropolis, and, apart from a very small number of identifiable areas, such as the inner city, and one or two suburbs which are predominantly settled by professional people, is fairly homogeneous in population. As a result, wide variations in school populations are not to be expected. The second reason was the limited time available for the study. To duplicate the group tests for small numbers of children in different schools would have demanded an expenditure of time far outweighing any real gains

in statistical certainty -- time which the schools could not afford to expend.

It was therefore decided to select three grades which might reasonably be expected to contain some children at each of two of Piaget's stages. Grade one might contain children at the pre-operational stage and children at the concrete operations stage; grade three might also contain children at these stages, and in addition might contain children showing the beginnings of formal operations; grade six should contain children at the concrete operations stage and, possibly, children at the formal operations stage. It was thought unlikely that there would be any children at the pre-operational stage in grade six.

It was also decided that the selection of one school would minimize interruption to the normal operations of schools, and, accordingly, a request was made for the allocation of one school in the north-east area of the city. This location was suggested because it avoided those areas of the city which could be classified as 'different' in some way, and increased the chances that the children would be typical of the children in Edmonton schools.

Although it was assumed that any variations of the sample from the population of grade one, grade three, and grade six children in Edmonton would be one-way with respect to intelligence, immediate memory span, logical level, and school achievement, this is obviously not necessarily so. In addition a one school sample greatly

diminishes the possibility of generalizing. Such evidence as the study reveals will be regarded as indicative of possible relationships, the direction and significance of which could only be established by an extensive longitudinal study.

The distribution of the sample by grade and sex is shown in Table I.

TABLE I

DISTRIBUTION OF THE SAMPLE BY GRADE AND SEX

Grade	Male	Female	Total
I	13	11	24
III	14	19	33
VI	14	13	27
Totals	41	43	84

The distribution of the sample by age is shown in Table II.

TABLE II

DISTRIBUTION OF THE SAMPLE BY AGE

Age in months	Number	Age in months	Number
77-78	4	121-122	2
79-80	6	129-130	1
81-82	5	131-132	2
83-84	4	...	...
85-86	5	137-138	2
...	...	139-140	5
97-98	1	141-142	6
99-100	-	143-144	6
101-102	7	145-146	3
103-104	6	147-148	1
105-106	6	149-150	-
107-108	5	151-152	1
109-110	2	153-154	1
111-112	2	...	...
...	...	159-160	1
Total	53		31

Grades three and six had recently been tested using Lorge-Thorndike Intelligence Test, which yields a verbal and a non-verbal

intelligence quotient. The authors indicate that an average of these may be used as a general intelligence quotient. The grade one class had been tested in September, 1969, using the Detroit Beginning Grade One Intelligence Test.

Since different tests had been used the distribution of the intelligence quotients is shown in three tables, Table III, Table IV, and Table V.

TABLE III

DISTRIBUTION OF INTELLIGENCE QUOTIENTS: GRADE I

(DETROIT BEGINNING GRADE ONE INTELLIGENCE TEST)

Intelligence Quotient	No.	Intelligence Quotient	No.
91-95	1	116-120	0
96-100	1	121-125	3
101-105	6	126-130	2
106-110	3	131-135	3
111-115	4	136-140	1
Totals	15		9

Mean intelligence quotient ... 114

Standard deviation ... 13

TABLE IV

DISTRIBUTION OF INTELLIGENCE QUOTIENTS: GRADE III

(LORGE-THORNDIKE INTELLIGENCE TEST, FORM 2, LEVEL A)

Intelligence Quotient	No.	Intelligence Quotient	No.
75-80	1	106-110	3
81-85	6	111-115	2
86-90	4	116-120	2
91-95	3	121-125	3
96-100	4	126-130	1
101-105	4		
Totals	22		11

Mean intelligence quotient ... 100
Standard deviation ... 16

TABLE V

DISTRIBUTION OF INTELLIGENCE QUOTIENTS: GRADE VI

(LORGE-THORNDIKE INTELLIGENCE TEST, FORM 3, LEVEL A)

Intelligence Quotient	No.	Intelligence Quotient	No.
81-85	1	106-110	5
86-90	2	111-115	2
91-95	2	116-120	4
96-100	3	121-125	2
101-105	6		
Totals	14		13

Mean intelligence quotient ... 105
Standard deviation ... 11

II. THE INSTRUMENTS

The immediate memory span test was the Digit Span Test of the Weschler Intelligence Scales for Children. It is an optional part of that test, and according to the Manual, scores on this test correlate at the .5 level with intelligence scores on the whole test.

The test consists of sets of digits. These are dictated one set at a time to the subject, at a rate of one digit per second approximately. On completion of the dictation of a set, the child is required to repeat the digits he has heard in the same order. If he fails, he is given an alternate set involving the same number of digits. If he fails again, the first part of the test is completed, and his score is the number of digits in the last set with which he was successful. If he is successful, the next set, which has one more digit, is dictated. The test proceeds until a maximum number of digits is obtained for the child. The test refers to this as the 'forward memory span'. The 'reverse memory span' is then obtained. The difference is indicated by the name. The child is required to reverse the order in which he hears the digits when repeating them. Again two trials are permitted at a given level before success or failure is recorded. The immediate memory span is calculated as the average of the forward and reverse spans.

The logical levels test consisted of two parts. The first

part contained five items based on Piaget's tests of conservation. The rationale for this section of the test is based on Piaget (1950), " ... there will be conservation of a whole, and this conservation itself will not be assumed by virtue of a probable induction, but affirmed by him as a certainty in his thought (p. 140)." The hallmark of the concrete operations stage is conservation, and hence success in conserving may be taken as indicative of the attainment of the logical level of concrete operations. Children who were successful on this part of the test were regarded as being at the concrete operations stage. 'Successful' on this part of the test means answering all the questions correctly. The children who did not answer all the questions correctly were regarded as being at the pre-operational stage.

The second part of the test consisted of fifteen items involving class logic, ordinal logic, and conditional logic. The concept of number is based on the construction of the groupings of classification and seriation (Piaget, 1950, p. 143). Hence logic involving these might be expected to manifest itself during the concrete operations stage. The groupings would also be necessary for formal operation involving classification and seriation. Test items related to the child's experience, and therefore having a concrete basis, might be successfully dealt with at the concrete operations level, while items involving completely hypothetical situations might only be successfully dealt with at the formal operations level. All the items in this part of the test were

based on Piaget's (1957) statement

> The new feature marking the appearance of the fourth stage is the ability to reason by hypothesis ... characterized by the possibility of accepting any sort of data as purely hypothetical and reasoning from them (p. 47).

It was noted that Hill's (1960) study indicated that subjects had considerable success with items which were (a) concrete, (b) probably within the child's experience, and (c) either valid with a conclusion supported by the child's experience, or invalid with a conclusion contradicted by the child's experience.

This suggested that items involving nonsense words, and hence outside the child's experience, items which were purely symbolic, and items which were valid but led to a conclusion contradicting the child's experience should prove good discriminators between the good guessers and those who had in fact reached the formal operations stage.

All parts of this test were administered orally, and oral responses were elicited from the children. A pilot study of this part of the logical levels test, involving twelve children from eight schools, revealed two children answering more than eleven items correctly. The probability that such scores could be obtained by chance is less than .03, and it was concluded that the test would offer some evidence of the achievement of the formal operations stage if twelve or more items were answered correctly.

Janis and Frick (1943) had indicated that children had

greater difficulty in judging the validity of items when either the conclusion of an invalid argument agreed with the truth as perceived by the child, or when the conclusion of a valid argument contradicted the truth as perceived by the child. On the basis of this finding and the result of the pilot study, the second section of the test, the formal operations section, was subdivided into two parts. Seven items based on items from Hill's (1960) study which consisted of valid arguments leading to conclusions which children could accept as true were together regarded as a subtest which will be referred to as Subtest VT (Valid-Truth), the remaining eight items included valid items leading to conclusions which children would perceive as false, invalid items leading to conclusions which children would perceive as true, and items using symbols or nonsense words for which the child would have no true-false scheme of identification. These items were together regarded as a subtest which will be referred to as Subtest IFS (Invalid, False, Symbolic).

For Subtest VT six or seven correct responses were regarded as evidence of success; for Subtest IFS seven or eight correct responses were regarded as evidence of success.

TABLE VI

CLASSIFICATION BY SUBTEST OF ITEMS ON THE FORMAL LOGIC SECTION OF THE LOGICAL LEVELS TEST

Subtest	Item Numbers	Total Number of Items
Valid-Truth (VT)	6, 7, 11, 12, 18, 19, 20	7
Invalid-False-Symbolic (IFS)	8, 9, 10, 13, 14, 15, 16, 17	8

Grades three and six were also given a group test in arithmetic and a group test in science. The California Achievement Test (1963 norms) was used for arithmetic. There are separate forms for upper primary (suitable for grade three) and elementary (suitable for grade six). To permit comparisons to be made between the two grades, the raw scores are converted to grade score equivalents. The tests are in two sections; the first tests knowledge of notation and problem-solving, the second tests skill in computation. The manual provides for conversion of the score on each part to a grade score equivalent.

Considerable difficulty was experienced in finding a suitable test in science which could be used for both grades three and six. Very few commercial tests are available for the primary grades. It was decided to use the Illustrated Science Test

devised by Reese and Peckens (1968) and modified in 1970 on the basis of a study conducted in Edmonton. The test, which is included in the Appendix, consists of 40 items, each item being composed of three pictures, only one of which is correct. The child is required to identify the correct picture by letter on his answer sheet. A recent study involving 1100 students in Edmonton public schools suggests that more refinement of the instrument is necessary, but yielded sufficient evidence to enable reasonable comparisons to be made between grades three and six science achievement. The Kuder-Richardson reliability figure of .69 should be borne in mind in assessing the correlations involving science achievement reported in Chapter IV of this study.

III. ADMINISTRATION OF THE TESTS

The individual tests were conducted in a counseling room made available by the school principal. Group tests in arithmetic and science were administered in the classroom. In order that minimum disturbance of the regular schedule would take place, the class teachers administered the arithmetic tests in parts at their own convenience.

To compensate for any learning factor, or fatigue factor, the order of the immediate memory span test and the logical levels test was reversed for successive children.

For the immediate memory span test one or two examples were given to ensure that the child understood what was required, then

the forward memory span was tested. After another example or two, the reverse memory span was tested. These were recorded and later averaged to provide the measure of immediate memory span.

A few minutes of explanation preceded the logical levels test. The first part, involving conservation, is explained item by item as the test proceeds and offers no difficulties. (The full instructions appear with the items in the Appendix). Several examples -- as many as the child needed -- of the following type were given to illustrate the difference between valid and invalid, and true and false. The words 'valid' and 'invalid' were printed on a piece of paper and remained in front of the child throughout this part of the test.

"If all boys/girls have red hair, and you are a boy/girl, then you have red hair." The colour was changed for those who had red hair. This was discussed until the child seemed to understand the required distinction. Then as many further examples as necessary were used until the investigator was confident that the child knew what was required.

The children were told that some of the items were valid and some were invalid. They were advised that all would probably <u>sound</u> valid at first, and they should take their time and think about each one carefully before answering. They were also told that an item would be repeated as often as they wished. In dictating these items, voice inflexion was kept to a minimum, but

it was noted that even so the items sounded valid.

Answers were noted on a score sheet attached to a clip board out of sight of the children. There was, therefore, no indication to the child of the correctness or otherwise of his answer.

IV. STATISTICAL PROCEDURES

An item analysis was carried out on the logical levels test. The internal consistency of the test was assessed by using the Kuder-Richardson Formula 20.

Correlations among the major variables were calculated using the DESTØ 2 program. Multiple Regression analysis using the MULRØ 5 program was used to control for various combinations of variables while examining the effect of one of the major variables. Scatter diagrams showing the relationships between pairs of the major variables, and distribution histograms of the variables were obtained by means of the DESTØ 6 program. All programs used were supplied by the Division of Education Research Services, University of Alberta, and the analysis was carried out on the IBM 360/67 computer at the University of Alberta.

The data, the results of the analysis, and an examination of the hypotheses in the light of the analysis are presented in Chapter IV.

CHAPTER IV

I. THE SAMPLE

A grade one class, a grade three class, and a grade six class of a school designated by the Edmonton Public School Board made up the sample for the study.

The school was situated in a middle class district of the city of Edmonton. The district was not characterized by any unusual ethnic,professional, or social concentration of population.

There were 24 grade one children, 33 grade three children, and 27 grade six children; a total of 84 subjects, 41 of whom were male, and 43 of whom were female. Ages ranged from six years five months to thirteen years four months.

The grade one children were tested using the Detroit Beginning Grade One Intelligence Test in September, 1969. The results of the tests were made available by the school. The distribution of intelligence quotients as determined by this test is shown in Table VI.

TABLE VI

DISTRIBUTION OF INTELLIGENCE QUOTIENTS: GRADE ONE
(DETROIT BEGINNING GRADE ONE INTELLIGENCE TEST)

Intelligence Quotient	No.	Intelligence Quotient	No.
91-95	1	116-120	0
96-100	1	121-125	3
101-105	6	126-130	2
106-110	3	131-135	3
111-115	4	136-140	1
Totals	15		9

Mean intelligence quotient ... 114

Standard deviation ... 13

Grade three and six had been tested in February, 1970. For grade three the Lorge-Thorndike Intelligence Test, Level 2, Form A, was used, and for grade six the Lorge-Thorndike Intelligence Test, Level 3, Form A, was used. Both tests yield a verbal and a non-verbal intelligence quotient and these may be averaged to yield a general intelligence quotient (Manual, Lorge-Thorndike Intelligence Test, 1963).

Tables VII and VIII, which show the distributions of intelligence quotients for grades three and six respectively, are based on the general intelligence quotients.

TABLE VII

DISTRIBUTION OF INTELLIGENCE QUOTIENTS: GRADE THREE

(LORGE-THORNDIKE INTELLIGENCE TEST, FORM 2, LEVEL A)

Intelligence Quotient	No.	Intelligence Quotient	No.
75-80	1	106-110	3
81-85	6	111-115	2
86-90	4	116-120	2
91-95	3	121-125	3
96-100	4	126-130	1
101-105	4		
Totals	22		11

Mean intelligence quotient ... 100
Standard deviation ... 16

TABLE VIII

DISTRIBUTION OF INTELLIGENCE QUOTIENTS: GRADE SIX

(LORGE-THORNDIKE INTELLIGENCE TEST, FORM 3, LEVEL A)

Intelligence Quotient	No.	Intelligence Quotient	No.
81-85	1	106-110	5
86-90	2	111-115	2
91-95	2	116-120	4
96-100	3	121-125	2
101-105	6		
Totals	14		13

Mean intelligence quotient ... 105
Standard deviation ... 11

II. TEST RESULTS

The distribution of scores on the Immediate Memory Span test, which is an optional sub-test of the Wechsler Test of Intelligence, is shown in Table IX. The results are generally in agreement with those found by other researchers (Munn, 1954, Wechsler, 1949).

TABLE IX

DISTRIBUTION OF IMMEDIATE MEMORY SPAN SCORES: GRADES I, III AND VI

Immediate Memory Span	Grade I	Grade III	Grade VI
3.0	3	1	-
3.5	11	8	1
4.0	7	13	5
4.5	3	5	6
5.0	-	5	6
5.5	-	-	5
6.0	-	-	3
6.5	-	-	1
Mean	3.7	4.1	4.9
Standard Deviation	.4	.5	.8

The Logical Levels Test consisted of three sub-tests. The first of these, the Conservation Sub-test, originally comprised six items. The first and the sixth items were physically identical. Two equal rows of candies were placed in one-to-one correspondence. The child was asked, "Which row has most candies, this row (pointing)

or this row (pointing) or do they both have the same?" One row was then spread out and for item one the question was repeated. For item six the question, "Which row would you like?" was asked. The child was given the row of his choice and was then asked, "Who got most, or did we both get the same number?" In very few cases did the answer to item six contradict that for item one, and in no case did it make any difference to the classification of the child as a conserver or a non-conserver. The item was therefore regarded as redundant and was dropped from the analysis. The percentage of correct responses by grade to the five items of the Conservation Sub-test are given in Table X.

TABLE X

PERCENTAGE OF CORRECT RESPONSES BY GRADE: CONSERVATION SUB-TEST

Item	Grade One	Grade Three	Grade Six	Total Sample
1	54	82	96	79
2	58	67	100	75
3	38	42	96	58
4	71	79	96	81
5	29	49	96	58

The reliability of this sub-test, as calculated by the Kuder-Richardson Formula 20, using the TESTO 3 program of the Division of Educational Research Services, University of Alberta, was .75.

The distribution of scores on the Conservation Sub-test are shown in Table XI.

TABLE XI

DISTRIBUTION OF SCORES ON THE CONSERVATION SUB-TEST

Score	Grade One	Grade Three	Grade Six
0	2	-	-
1	6	4	-
2	4	10	1
3	6	3	-
4	2	9	1
5	4	7	25
Mean	2.5	3.2	4.9
Standard Deviation	1.6	1.4	.6

The second sub-test of the Logical Levels Test consisted of items with valid arguments leading to conclusions which the child could accept as true. The sub-test is referred to as the Sub-test VT (Valid-truth). The Kuder-Richardson Formula 20 reliability was calculated as .749.

The third sub-test of the Logical Levels Test contained items with invalid arguments leading to conclusions which the child could accept as true, valid arguments leading to conclusions which contradict the child's experience, and which he is likely to regard

as false, and items using symbols or nonsense words. This test is referred to as Sub-test IFS (Invalid, False, Symbolic). The Kuder-Richardson Formula 20 reliability was calculated as .31.

The two sub-tests were administered as one with items from each randomly included but presented in the same order to each child. The percentages of correct responses for these sub-tests are given in Table XII in the order in which the items were presented during the test. An asterisk is used to identify the items which constitute Sub-test VT.

TABLE XII

PERCENTAGES OF CORRECT RESPONSES BY GRADE: SUB-TEST VT(*) AND SUB-TEST IFS

Item	Grade One	Grade Three	Grade Six	Total
6*	38	88	100	77
7	13	21	4	13
8*	21	48	74	49
9	29	33	8	24
10	13	36	52	34
11*	33	64	78	60
12*	50	82	81	73
13	21	33	41	32
14	25	24	22	24
15	29	45	48	42
16	25	27	15	22
17	21	24	8	18
18*	46	64	85	65
19*	33	67	70	58
20*	63	88	81	79

The distribution of scores on Sub-test VT by grades is shown in Table XIII.

TABLE XIII

DISTRIBUTION OF SCORES ON SUB-TEST VT:

GRADES ONE, THREE, AND SIX

Score	Grade One	Grade Three	Grade Six
0	6	-	-
1	2	-	-
2	3	2	-
3	3	5	2
4	3	4	4
5	4	9	5
6	2	6	6
7	1	7	10
Mean	2.8	5.0	5.7
Standard Deviation	2.3	1.5	1.4

The distribution of scores on Sub-test IFS by grades is shown in Table XIV.

TABLE XIV

DISTRIBUTION OF SCORES ON SUB-TEST IFS:

GRADES ONE, THREE, AND SIX

Score	Grade One	Grade Three	Grade Six
0	8	3	2
1	3	7	8
2	6	7	9
3	4	5	5
4	2	7	2
5	1	4	1
6,7,8	-	-	-
Mean	1.7	2.5	1.9
Standard Deviation	1.6	1.5	1.2

Grade three and six were tested for Arithmetic achievement using the California Achievement Test. Upper Primary, Form W, was used for grade three, and Elementary, Form W, was used for grade six. Each of these yield two scores, one for 'Notation and Problem solving', and one for 'Computation'. These may be converted by means of a table in the Manual (1963) to grade scores. The distribution of grade scores on each part of the test for grade three is given in Table XV.

TABLE XV

DISTRIBUTION OF ARITHMETIC ACHIEVEMENT BY GRADE SCORES,

CALIFORNIA ACHIEVEMENT TEST : GRADE THREE

Grade Scores	Notation & Problem Solving	Computation
2.8-3.0	-	2
3.1-3.3	1	3
3.4-3.6	2	1
3.7-3.9	5	9
4.0-4.2	6	6
4.3-4.5	10	7
4.6-4.8	8	3
4.9-5.1	1	2
Mean	4.1	3.8
Standard Deviation	.5	.6

The distribution of grade scores on each part of the Arithmetic test for grade six is given in Table XVI.

TABLE XVI

DISTRIBUTION OF ARITHMETIC ACHIEVEMENT BY GRADE SCORES, CALIFORNIA ACHIEVEMENT TEST : GRADE SIX

Grade Scores	Notation & Problem Solving	Computation
4.9-5.1	1	-
5.2-5.4	1	-
5.5-5.7	2	2
5.8-6.0	1	4
6.1-6.3	3	1
6.4-6.6	8	1
6.7-6.9	3	2
7.0-7.2	3	3
7.3-7.5	4	4
7.6-7.8	1	7
7.9-8.1	-	1
8.2-8.4	-	1
8.5-8.7	-	1
Mean	6.5	6.8
Standard Deviation	.8	1.3

The Illustrated Science Test (Reese and Peckens, 1968) was used to test for science achievement in grades three and six. Although the test was revised in January, 1970, for grades five and six, it was felt that the pictorial nature of the test made it appropriate for grade three. The reliability of the test for grade six in a study involving over 500 grade six students conducted in

Edmonton in May, 1970 was .67. The reliability for the grade three students in the present study was calculated to be .69. The distributions of science scores for grades three and six are given in Table XVII.

TABLE XVII

DISTRIBUTION OF SCORES ON ILLUSTRATED SCIENCE TEST :
GRADES THREE AND SIX

Score	Grade Three	Grade Six
7-8	2	-
9-10	3	-
11-12	6	-
13-14	4	-
15-16	6	4
17-18	7	6
19-20	2	3
21-22	3	2
23-24	-	5
25-26	-	6
27-28	-	-
29-30	-	1
Mean	13.7	21.0
Standard Deviation	3.9	3.9

III. STATISTICAL ANALYSIS : THE HYPOTHESES

In this section each hypothesis is tested in the light of analysis of the data obtained in the investigation.

Hypothesis 1 There is no relationship between immediate memory span and logical level.

Correlations between immediate memory span and scores on (a) the Conservation sub-test, (b) Sub-test VT, (c) Sub-test IFS, and (d) the whole logical levels test were obtained. The calculations were carried out for each grade separately and for the whole sample. The correlations are presented in Tables XVIII, XVIX, XX and XXI.

TABLE XVIII

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
LOGICAL LEVELS TEST SCORES : GRADE ONE

Immediate Memory Span	N = 24	Correlation	t-ratio
Conservation sub-test		.33	1.63
Sub-test VT		.06	.26
Sub-test IFS		.52**	2.84
Total test		.35	1.75

** Significant at or beyond the .01 level

TABLE XVIX

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
LOGICAL LEVELS TEST SCORES : GRADE THREE

Immediate Memory Span N = 33	Correlation	t-ratio
Conservation sub-test	.49**	3.17
Sub-test VT	.39**	2.34
Sub-test IFS	-.26	-1.47
Total test	.43*	2.62

** Significant at or beyond the .01 level
* Significant at or beyond the .05 level

TABLE XX

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
LOGICAL LEVELS TEST SCORES : GRADE SIX

Immediate Memory Span N = 27	Correlation	t-ratio
Conservation sub-test	.44*	2.27
Sub-test VT	.41*	2.25
Sub-test IFS	-.30	-1.56
Total test	.17	.79

* Significant at or beyond the .05 level

TABLE XXI

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
LOGICAL LEVELS TEST SCORES : WHOLE SAMPLE

Immediate Memory Span N = 84	Correlation	t-ratio
Conservation sub-test	.61***	6.89
Sub-test VT	.48***	4.91
Sub-test IFS	-.06	-.54
Total test	.52***	5.43

*** Significant at or beyond the .001 level

Multiple linear regression models were constructed to test the significance of immediate memory span as a predictor of logical level. The analysis examined the significance of immediate memory span as a predictor of scores on the sub-tests and on the total test scores.

A full model was constructed in which all the variables measured were used in a linear model to predict scores on the conservation sub-test. A restricted model which omitted immediate memory span scores was constructed, and the full model was then compared with the restricted model to yield an F-ratio.

Further models were constructed by eliminating one more variable in each model. Thus successive pairs of models could be compared to yield F-ratios. In each case the F-ratio indicated the significance of immediate memory span as a predictor of conservation sub-test scores over and above the other variables included in the particular pair of models.

The process was repeated for each sub-test and for the total test scores. The analysis was carried out for grades three and six separately and together, since the same variables had been measured for these two classes. This yielded 96 F-ratios and would be too cumbersome to report in full. A verbal summary with relevant statistics follows.

SUMMARY OF RESULTS
OF
MULTIPLE LINEAR REGRESSION ANALYSIS : GRADE THREE

(1) Immediate memory span is a significant predictor of conservation sub-test scores over and above all other variables together. (F-ratio, 4.46; d.f.,1/24; significant beyond the .05 level).

(2) Immediate memory span is a significant predictor of VT sub-test scores over and above all other variables taken together. (F-ratio, 5.43; d.f.,1/24; significant beyond the .05 level).

(3) Immediate memory span is not a significant predictor of IFS sub-test scores. (F-ratio, 2.31; d.f.,1/31; not significant).

(4) Immediate memory span is a significant predictor of total logical levels test scores over and above all other variables taken together. (F-ratio, 7.56, d.f.,1/24; significant beyond the .05 level).

SUMMARY OF RESULTS
OF
LINEAR REGRESSION ANALYSIS : GRADE SIX

(1) Immediate memory span is a significant predictor of conservation sub-test scores over and above verbal and non-verbal intelligence quotients, mathematics notation and problem solving scores, and mathematics computation scores. (F-ratio, 4.66;

d.f.,1/21; significant beyond the .05 level).

(2) Immediate memory span is a significant predictor of VT sub-test scores over and above verbal and non-verbal intelligence quotients, mathematics notation and problem solving scores, and mathematics computation scores. (F-ratio, 4.46; d.f.,1/21; significant beyond the .05 level).

(3) Immediate memory span is not a significant predictor of IFS sub-test scores. (F-ratio, 2.65; d.f.,1/25; not significant).

(4) Immediate memory span is not a significant predictor of total logical levels test scores. (F-ratio, 1.24; d.f.,1/25; not significant).

SUMMARY OF RESULTS
OF
MULTIPLE LINEAR REGRESSION ANALYSIS : GRADES THREE & SIX COMBINED

(1) Immediate memory span is a significant predictor of conservation sub-test scores over and above all the other variables measured taken together. (F-ratio, 7.62; d.f.,1/51; significant beyond the .01 level).

(2) Immediate memory span is a significant predictor of VT sub-test scores over and above all the other variables measured taken together. (F-ratio, 5.66; d.f.,1/51; significant beyond the .05 level).

(3) Immediate memory span is a significant predictor of IFS sub-test scores over and above verbal and non-verbal

intelligence quotients, mathematics notation and problem solving scores, and mathematics computation scores. (F-ratio, 4.21; d.f.,1/54; significant beyond the .05 level).

(4) Immediate memory span is a significant predictor of total logical levels test scores over and above mathematics computation scores. (F-ratio, 5.26; d.f.,1/57; significant beyond the .05 level).

A better appreciation of the significance of immediate memory span as a predictor of the various scores may be obtained from Table XXII which gives the proportion of the variance accounted for by immediate memory span for each of the sub-tests and for the total test.

TABLE XXII

PROPORTION OF VARIANCE ACCOUNTED FOR BY IMMEDIATE MEMORY SPAN IN LINEAR REGRESSION MODELS

Test	Grade Three	Grade Six	Grades Three & Six
Conservation	26.1%	13.7%	35.9%
VT sub-test	16.0%	18.1%	20.3%
IFS sub-test	6.9%	9.6%	10.9%
Total test	19.3%	4.7%	21.9%

On the basis of the analysis above, hypothesis 1 must be rejected. There exists a significant relationship between immediate

memory span and logical level, particularly with respect to the concrete operations level as determined by a test of conservation. The multiple linear regression analysis indicated that immediate memory span is a significant predictor of conservation sub-test scores and the VT sub-test scores at the grade three level and at the grade six level.

<u>Hypothesis 2</u> There is no relationship between immediate memory span and (a) Intelligence quotient (b) mathematics achievement (c) science achievement.

It was possible to test this hypothesis fully for grades three and six only, since the grade one class was not tested for mathematics achievement nor for science achievement. Correlations were calculated between appropriate pairs of variables and these are presented in subsequent tables. Table XXIII gives the correlations for grade one.

TABLE XXIII

CORRELATION OF IMMEDIATE MEMORY SPAN
AND
INTELLIGENCE QUOTIENT : GRADE ONE

Immediate memory span	N = 24	Correlation	t-ratio
Intelligence quotient		.35	1.78

The appropriate correlations for grade three are given in Table XXIV.

TABLE XXIV

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
(A) VERBAL INTELLIGENCE QUOTIENTS
(B) NON-VERBAL INTELLIGENCE QUOTIENTS
(C) SCIENCE SCORES
(D) MATHEMATICS, NOTATION & PROBLEM SOLVING SCORES
(E) MATHEMATICS, COMPUTATION SCORES
: GRADE THREE

Immediate memory span	N = 33	Correlation	t-ratio
Verbal intelligence quotient		.45**	2.80
Non-verbal intelligence quotient		.39*	2.38
Science score		.32	1.89
Mathematics, notation & problem solving		.47**	2.98
Mathematics, computation		.12	.65

* Significant at or beyond the .05 level
** Significant at or beyond the .01 level

The appropriate correlations for grade six are presented in Table XXV.

TABLE XXV

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
(A) VERBAL INTELLIGENCE QUOTIENTS
(B) NON-VERBAL INTELLIGENCE QUOTIENTS
(C) SCIENCE SCORES
(D) MATHEMATICS, NOTATION & PROBLEM SOLVING SCORES
(E) MATHEMATICS, COMPUTATION SCORES
: GRADE SIX

Immediate memory span N = 27	Correlation	t-ratio
Verbal intelligence quotient	.06	.28
Non-verbal intelligence quotient	.18	.93
Science score	.12	.63
Mathematics, notation & problem solving	.16	.82
Mathematics, computation	.11	.54

The appropriate correlations for the combined grades three and six are presented in Table XXVI.

TABLE XXVI

CORRELATIONS OF IMMEDIATE MEMORY SPAN
AND
(A) VERBAL INTELLIGENCE QUOTIENTS
(B) NON-VERBAL INTELLIGENCE QUOTIENTS
(C) SCIENCE SCORES
(D) MATHEMATICS, NOTATION & PROBLEM SOLVING SCORES
(E) MATHEMATICS, COMPUTATION SCORES

: GRADES THREE AND SIX COMBINED :

Immediate memory span	N = 60	Correlation	t-ratio
Verbal intelligence quotient		.28*	2.11
Non-verbal intelligence quotient		.21	1.61
Science score		.50***	4.39
Mathematics, notation & problem solving		.58***	5.46
Mathematics, computation		.50***	4.40

* Significant at or beyond the .05 level

*** Significant at or beyond the .001 level

In view of these analyses, hypothesis 2 cannot be accepted. There is a significant relationship between immediate memory span and verbal intelligence quotient, between immediate memory span and non-verbal intelligence quotient at the grade three level; and there are significant correlations between immediate memory span and science scores, and immediate memory span and both mathematics scores for the combined grades three and six.

The data obtained included the ages of the subjects and, although no hypothesis involving age was advanced, correlations between age and other variables were calculated. These are given in Table XXVII.

TABLE XXVII

CORRELATIONS BETWEEN AGE, IMMEDIATE MEMORY SPAN
AND
LOGICAL LEVELS SUB-TESTS

: WHOLE SAMPLE :

Age	Correlation	t-ratio
Immediate memory span	.57***	6.35
Conservation sub-test scores	.57***	6.25
VT sub-test scores	.49***	5.14
IFS sub-test scores	.06	.54

*** Significant beyond the .001 level

Scatter diagrams illustrating the relationships between age and immediate memory span, and between immediate memory span and conservation scores are presented on the following pages.

IV. SUMMARY

The results of the analysis indicate that the two hypotheses, first that there exists no relationship between immediate memory span and logical level, and second, that there exist no significant relationships between immediate memory span and intelligence quotients, and between immediate memory span and academic achievement as measured by mathematics and science tests, must both be rejected.

The study revealed that there exist significant relationships between immediate memory span and logical level for the whole sample, between immediate memory span and intelligence quotients at the grade three level, and between immediate memory span and academic achievement as measured by mathematics and science tests for the combined grades three and six.

The implications of the findings and recommendations for further research resulting from the study are presented in the next chapter.

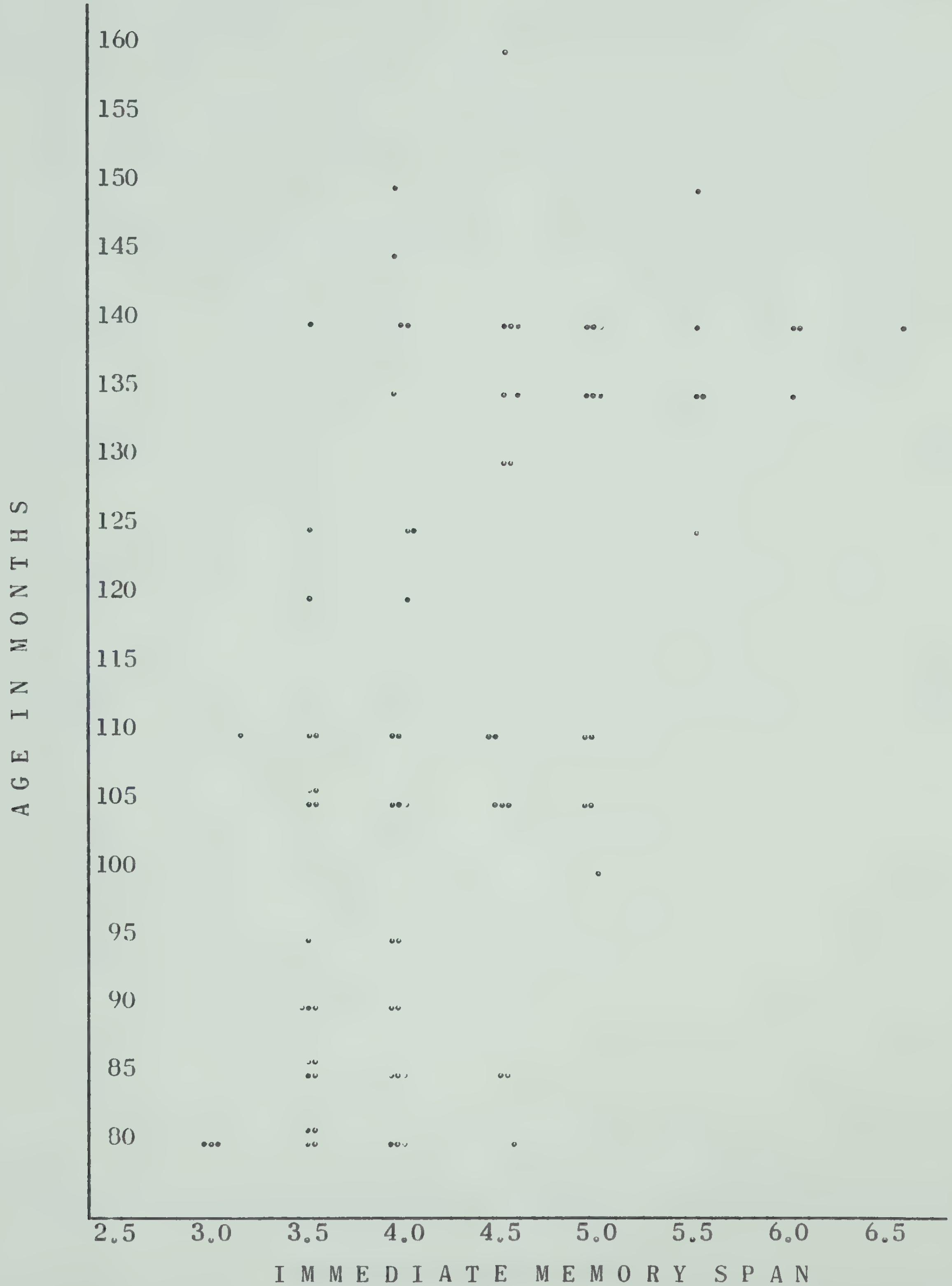

FIGURE 1

SCATTER DIAGRAM FOR AGE AND

IMMEDIATE MEMORY SPAN

(N = 84) (r = .57)

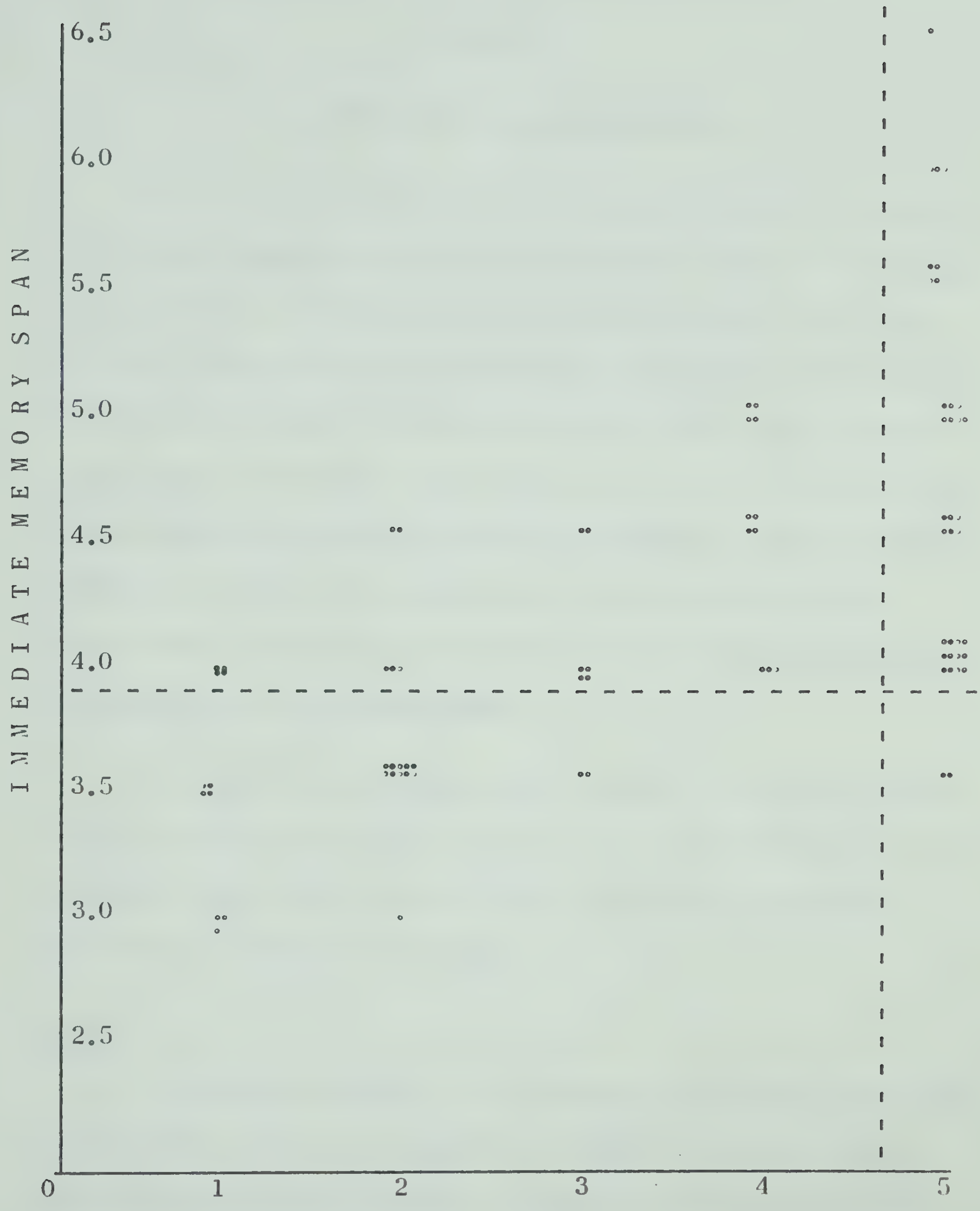

FIGURE 2

SCATTER DIAGRAM FOR IMMEDIATE MEMORY SPAN AND CONSERVATION SCORE

(N = 84) (r = .61)

CHAPTER V

I. SUMMARY OF THE INVESTIGATION

The study was designed to investigate a possible relationship between immediate memory span and logical level in elementary school children. The logical level implies the particular stage in Piaget's description of intellectual development which has been reached by the child. It was assumed that three stages, the preoperational, the concrete operational, and the formal operational stages would be present in a sample of elementary school children ranging from grade one to grade six. The role of immediate memory span as a predictor of mathematics achievement and science achievement was also investigated.

To gather the necessary data a sample of grade one, grade three and grade six children was obtained, and instruments testing immediate memory span, logical level, mathematics achievement, and science achievement were used.

Sample

The sample consisted of all the pupils in a grade one class, a grade three class, and a grade six class in a school in the Edmonton Public School system. A school in the north-east area of the city was requested to avoid areas of the city which include populations that for one reason or another are atypical. The area in which the school is situated can be described as middle class.

The ages of the children ranged from 77 months to 160 months.

Two different tests of intelligence had been used by the school and the results of these were made available. The grade one class were tested in September, 1969, using the Detroit Beginning Grade One Intelligence Test; scores ranged from 95 to 136. The grade three and grade six children were tested in February, 1970, using the Lorge-Thorndike Intelligence Test, Form A, Level II; scores ranged from 80 to 130.

<u>Instruments</u>

The Digit Span Test of the Wechsler Intelligence Scales, Children (Manual, 1949) was used as a test of immediate memory span. Sets of digits are read to the child at an approximate rate of one digit per second, and the child is required to repeat the digits correctly. If he fails, a second set containing the same number of digits is read to him. If he fails to repeat them accurately, his score is the number of digits in the last successful set. If he is successful at the first or second trial a fresh set of digits with one more digit is read to him. The test has a second part in which the child is required to reverse the order of the digits when presenting them orally to the investigator. The final score is the average of the scores on the two parts. Thus it is possible to record an immediate memory span of 4.5 although obviously an individual cannot remember half a digit.

The logical level was measured using an instrument (Appendix) consisting of five items testing conservation derived from

Reimer (1968) and fifteen items testing formal thinking derived from Ennis and Dieter (1965) and Hill (1960). These fifteen were sub-divided into a seven item sub-test which included items with valid arguments leading to conclusions which the child would regard as true (referred to as the Sub-test VT), and an eight item sub-test containing items with invalid arguments or conclusions which the child would regard as false, or symbolic items (referred to as the Sub-test IFS). The K-R 20 reliability of the test was .68.

Mathematics achievement in grades three and six was measured using the California Achievement Test. The Upper Primary, Form W, was used for grade three, and the Elementary, Form W, was used for grade six. Scores were converted to grade equivalents using a table provided in the manual.

Science achievement was measured using the Illustrated Science Test developed by Reese and Peckens in 1968 and revised in 1970 (Appendix). The test yielded K-R 20 reliability of .67 with a sample of over 1100 grades five and six children in a 1970 study; the K-R 20 reliability for the grade three children in the present study was .69.

Computer programs supplied by the Division of Educational Research Services, University of Alberta, were used to analyze the data.

II. SUMMARY OF FINDINGS

It was found that a significant correlation existed between immediate memory span and logical level as represented by total score on the logical level test. Significant correlations between immediate memory span and scores on the conservation sub-test, and between immediate memory span and scores on the Sub-test VT were obtained.

Analysis of the data for each grade separately revealed that the correlations referred to above were significant at the grade three level, while at the grade one level a significant correlation was found to exist between immediate memory span and scores on Sub-test IFS, but no significant correlation existed between immediate memory span and conservation scores, between immediate memory span and Sub-test VT scores, nor between immediate memory span and total test scores. For grade six there existed significant correlations between immediate memory span and both conservation and Sub-test VT scores, but not between immediate memory span and Sub-test IFS, nor between immediate memory span and total test scores.

For grades three and six, multiple linear regression analysis revealed that immediate memory span is a significant predictor of scores on the conservation Sub-test and the Sub-test VT over and above all other variables measured. Immediate memory span is a significant predictor of total logical levels test scores

over and above mathematics computation scores.

For grades three and six significant correlations existed between immediate memory span and (i) verbal intelligence quotient, (ii) science scores, (iii) mathematics notation and problem solving scores, and (iv) mathematics computation scores.

III. DISCUSSION AND IMPLICATIONS

The findings indicate that, particularly at the grade three level, immediate memory span correlates significantly with logical level as defined in this study. Janis and Frick (1943) reported that errors in judging syllogisms were more likely in valid arguments leading to conclusions which contradicted the experience of the subject, and in invalid arguments leading to conclusions which agreed with the experience of the subject. This leaves only those syllogisms in which a valid argument leads to a true conclusion, or syllogisms in which invalid argument leads to a false conclusion. In such examples it seems likely that it is the conclusion which is being judged and not the validity of the argument. If this is the case then the only items in Janis and Frick's study which test the ability to judge the validity of a syllogism are precisely those in which most errors are likely to be made.

The same point may be made about the items in the logical levels test used in the present study. However, the classification of items into three sub-tests revealed a definite growth in the

subject's ability to deal with conservation problems and with logical arguments which were valid arguments leading to true conclusions, but not in their ability to deal with invalid arguments or arguments leading to false conclusions or symbolic arguments. Grade one handled such items with more success than grade six.

This anomaly requires explanation. There seem to be two possibilities. It may be that the older children have learned that answers in tests tend to be less than obvious. Thus they are a little suspicious of their own intuition, and when they are in doubt they may use this suspicion as the final criterion, thus arriving at the wrong conclusion. The anomaly may, however, be due to the fact that the grade six children are approaching the formal operations stage. Structures are being created which in certain situations enable them to make correct judgements. The mental operations are not yet integrated into a system, and consequently there are some situations, particularly those which are hypothetical, for which the structures do not yet provide logical certainty but do seem to inhibit the intuition displayed by the younger child. This explanation would also indicate why the older children were better at judging valid arguments leading to true conclusions than were the younger children. They are, in other words, at a higher level of intellectual development than the younger children.

The correlations between age and scores on the conservation Sub-test and Sub-test VT scores respectively seem to suggest that

maturation is an important factor in intellectual development. Whether the rate of differentiation and specialization of organic structures, which is what Piaget (1960) implies by the term maturation, can be accelerated is a matter of speculation. Studies of immediate memory span indicate remarkable agreement on the span associated with a particular age. Attempts at improving memory seem to depend on what Miller (1956) calls chunking, and what other writers refer to as coding. What is involved is some process of grouping the single units of information so that the group may be remembered as a single piece. This does not improve the memory span, it merely changes the unit spanned. Thus while it may be possible to improve memory it seems unlikely that immediate memory span itself is improved in the process.

Hunter (1964) quotes a comment made by William James (1891) in reference to the good memory for facts displayed by people in connection with their own pursuits, for example, the sportsman who is a walking dictionary of sports statistics. James makes the point that for such a man facts form a concept system. In such a system facts are retained by their relationship to other facts. Again the idea of coding seems to underlie the gain in memory.

There are occasional instances, the most famous, perhaps, being the mnemonist Shereshevski described by Luria (1960), of people with almost unlimited memory capacities. Unfortunately Luria does not report the immediate memory span of his subject, but it is clear from the detailed description of Shereshevski's

method that a learning process was used to commit material to memory. He used a technique of pervasive imagery that enabled him to memorize with detailed precision, but the method also had the effect of tying him to a sensory knowledge of his material. Luria managed to get Shereshevski a job with a railroad but, because he was unable to abstract relationships from the material that he memorized, he was unsuccessful at the job.

It seems conceivable that unusual memory gains are only achieved at the cost of a loss in understanding. Piaget's theory that memory is imbedded in the cognitive structure (Furth, 1969) may require some qualification with regard to capacity. As with a computer there may be a limit to the total capacity of the brain, the more of the capacity that is used for memory the less will be available for operational thinking. Immediate memory span, to pursue the analogy a little further, may be compared to the size of the work space of the computer.

It is important to distinguish between memory and immediate memory span. Until relationships are established, facts are separate pieces of information. Thus in the acquisition of concepts one fact may be related to another. Another fact is tested against this relationship and either integrated with it or rejected. Thus the twin processes of assimilation and accommodation which constitute equilibration are at work. In designing curriculum appropriate for an individual, one may need to consider the immediate memory span required for the acquisition of a particular

concept, such as conservation of number, or a particular skill, such as solving a problem in mathematics or science. Treacy (1944) found that good and poor achievers on arithmetic tests differed significantly on retention of clearly stated details. This suggests that some pupils find problem solving difficult because they are unable to retain significant facts. Treacy goes on to conclude that, "instruction should be designed accordingly (p. 96)." It may well be that analysis of concepts or skills in terms of immediate memory span requirements could lead to basic information in curriculum design.

The analysis of the data may be interpreted as providing limited support for the hypothesis put forward by McLaughlin (1960) that an immediate memory span of four units is necessary for the concrete operations stage. Only two subjects whose immediate memory spans were less than four were successful on all items in the conservation Sub-test. Success on this sub-test was regarded as evidence that the subject was in the concrete operations stage. Each of the two subjects had an immediate memory span score of three-and-a-half, which resulted from averaging two scores. It seems likely, since the immediate memory span must be a whole number, that in both cases it was actually four.

McLaughlin suggests that an immediate memory span of eight is required for the formal operations stage, and while no positive evidence was obtained to support this, it was noted that the subjects with an immediate memory span of six or more were the top

scores on the logical levels test as a whole. No subject satisfied the criterion set for formal operations -- a score of six or seven on the Sub-test VT and a score of seven or eight on the Sub-test IFS -- and no subject displayed an immediate memory span of eight, so that there was no evidence on the basis of which McLaughlin's hypothesis could be rejected.

III. RECOMMENDATIONS FOR FURTHER RESEARCH

Although the conservation Sub-test and the Sub-test VT yielded K-R 20 reliability figures which suggested that they were reasonably internally consistent, the low figure for the Sub-test IFS indicates that it was an inappropriate instrument for children at this level. The significant correlations which were found suggest that there may be a profitable line of inquiry to be derived from the study.

Two ways are suggested in which this inquiry may be pursued.

Since many school beginners are in the pre-operational stage efforts should be made to determine the relationship between immediate memory span and the classification skills which characterize the pre-operational stage. At this stage the child lacks reversibility and hence tasks which require reversibility may be included in classification testing. Thus it may be possible to derive by scalogram analysis a hierarchy of classification skills in the way that Kofsky (1966) attempted, and, at the same time to measure immediate memory span, and test for relationship

between classification scores and immediate memory span.

The concrete operations stage is characterized, according to Piaget (1959), by conservation, and during this stage various conservations develop. There seems to be lack of unanimity on the order in which these appear, but certainly conservation of number, conservation of quantity, both continuous and discrete, conservation of length, of area, of volume, do not appear simultaneously. This suggests another possible investigation in which the possible existence of a hierarchy of conservations can be examined, and at the same time, an investigation of the relationship between immediate memory span and these conservations.

Both investigations would have the same purpose as the present study, to investigate relationships which, if significant, could provide curriculum builders with fundamental determinants of appropriate concepts and skills.

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A P P E N D I X

LOGICAL LEVELS TEST

LOGICAL LEVELS TEST

A. CONSERVATION SUB-TEST

(Based on the assumption that the transition from Stage II -- the pre-operational stage -- is marked by the acquisition of conservation).

(1) Two rows of six candies (the kind called 'Smarties' in Canada) were matched in one-to-one correspondence. The child was asked, "Which row has most candies, this row (pointing to one row) or this one (pointing to the other row), or do they both have as many candies?" The candies in one row were then spread out and the question was repeated.

(2) The child and the examiner each had identical plastic containers into which they each placed one candy at a time. After each addition agreement was obtained that "we both have as many candies" -- in some cases the process had to be started more than once before the child agreed that after each addition of one candy, the number of candies was the same in both containers. The investigator then poured his candies into a shallow, wide container, and asked, "What about now?"

(3) Two sticks of equal lengths were placed parallel to one another with their ends in line. The investigator asked, "Which stick is longer, this one (pointing to one stick) or this one (pointing to the other stick) or are they both as long? One

stick was then moved laterally so that the sticks remained parallel but the ends were no longer in line, and the question was repeated.

(4) Fifteen glass marbles, twelve of which were blue and three of which were orange colour, were placed in a dish. The child was asked what they were made of, and whether they were all made of glass. He was then asked, "Are there more blue marbles or more orange marbles, or are there the same number of each?" followed by, "Are there more blue marbles or are there more glass marbles or are there the same number of each?

(5) A chart on which two concentric circles of coloured discs had been pasted was shown to the child. The outer circle contained twelve red discs in positions corresponding to the hour positions on a clock. The inner circle having a radius half that of the outer circle, contained twelve blue discs of the same size as the red discs, also arranged in the hour positions. The child was asked, "Are there more red discs, or more blue discs, or the same number of each?"

B. VT (Valid-Truth items) and IFS (Invalid-False-Symbolic items) SUB-TESTS

Based on Piaget (1950), "... formal reasoning connects assumptions, ... propositions, that is, in which one does not necessarily believe (p. 251)."

These Sub-tests were administered as one, items marked with an asterisk are VT items, unmarked items are IFS items.

ADMINISTRATION OF SUB-TESTS VT AND IFS

The words VALID and INVALID were printed on paper which was left on the desk throughout the test. The required distinction was explained to the child in the following way.

The child was asked, "If all boys/girls have red hair, and you are a boy/girl, then you have red hair -- is that true?" (If the child had red hair, the word "brown" was substituted for "red"). The child invariably said, "No." "You are quite right, it is not true that you have red hair. But notice what the words were -- if all boys/girls have red hair -- if we pretend that all boys/girls have red hair, then what colour would your hair be?" The child usually answered, "Red" at this point. If he did not then other examples of a similar nature were made up. Examples involving the relative positions of the child and the investigator, or involving the relationship between the child and the investigator were used until the investigator felt that the child understood the distinction between True/False and Valid/Invalid.

The child was repeatedly reminded to pretend that the first lines of the story were true, and then see if he could figure out whether the last lines would be true. He was asked to say "Valid" or "Invalid" but in fact any response which seemed to be his way of indicating his judgement of validity was accepted.

The items were repeated orally as often as the child wished. The investigator attempted to keep voice inflection to a minimum throughout the test.

SUB-TESTS VT AND IFS

(* Indicates items on the VT SUB-test, items not marked are items on the IFS Sub-test).

*6. All John's pencils are blue

This is one of John's pencils

Therefore it is blue.

7. All the red books are Mary's

Therefore all Mary's books are red.

*8. All Tom's homework is due today

None of the homework due today is Arithmetic

Therefore none of Tom's homework is Arithmetic.

9. All cronks are glucks

This is a gluck

Therefore this is a cronk.

10. Only horses with six legs run fast

No horses have six legs

Therefore no horses run fast.

*11. Mary runs faster than Susan

Susan runs faster than Jean

Therefore Mary runs faster than Jean.

*12. Joe is taller than Bill

Frank is shorter than Bill

Therefore Frank is the shortest of all three.

13. Tom jumps higher than Dick

Dick jumps lower than Bob

Bob is the lowest jumper of all three.

14. A trod is bigger than a glup

A glup is smaller than a flim

Therefore a trod is bigger than a flim.

15. X is more than Z

Y is more than Z

Therefore X is more than Y.

16. If the hat is blue it is Joan's

The hat is not blue

Therefore it is not Joan's.

17. If Mary lives next door her name is Brown.

Her name is Brown

Therefore she lives next door.

*18. If the car in the garage is mine, it is blue

The car in the garage is not blue

Therefore it is not mine.

*19. If Mrs. Smith entered the flower show, she entered her roses

Mrs. Smith did not enter her roses

Therefore she did not enter the flower show.

*20. Tom is on the football team only if he has his mother's permission

He is on the football team

Therefore he has his mother's permission.

ILLUSTRATED SCIENCE TEST

THREE FRAME FORM

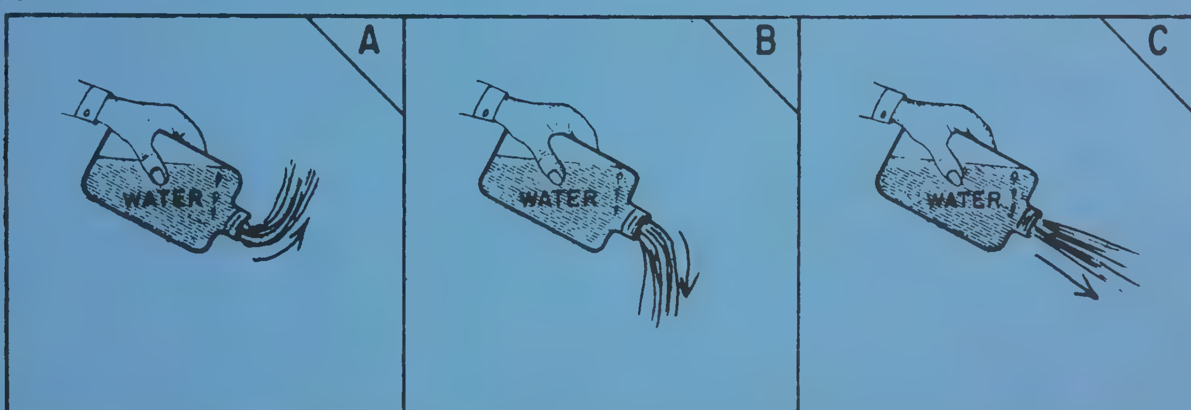
© Willard F. Reese and Russell G. Peckens, 1968

This test is different from any other you have ever taken before. It is designed to test your knowledge of scientific facts and concepts, your powers of observation, and your ability to reason and use good judgement. Each of these factors is of great importance to scientists and technicians.

DIRECTIONS

This is the test booklet. Do not mark or write in any way upon the pages of this booklet. In this test each question consists of three illustrated frames. Only one of the three frames shown for each question will be correct. The frames are labeled A, B and C. [redacted]

In the sample question below there are three illustrations of water being poured from a bottle. Frame B is a correct illustration because it shows the water flowing down from the bottle. Frames A & C are not correct.



(Note: The arrows indicate the direction of movement.)

Since B is the correct answer, the space under B in the example shown on your answer sheet is marked like this

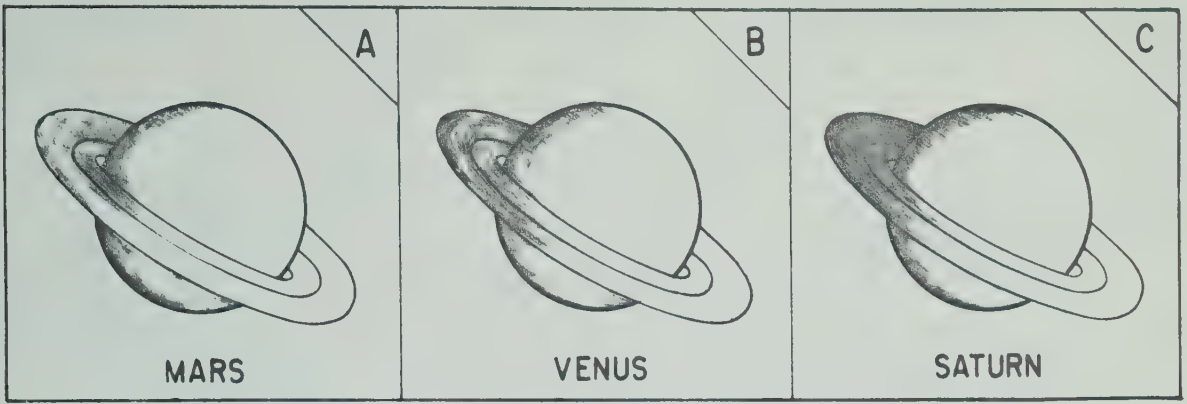
Make a similar pencil mark (under A or B or C, for each question) to show which answer is correct. Notice that you need mark only A or B or C; there are no D or E answers.

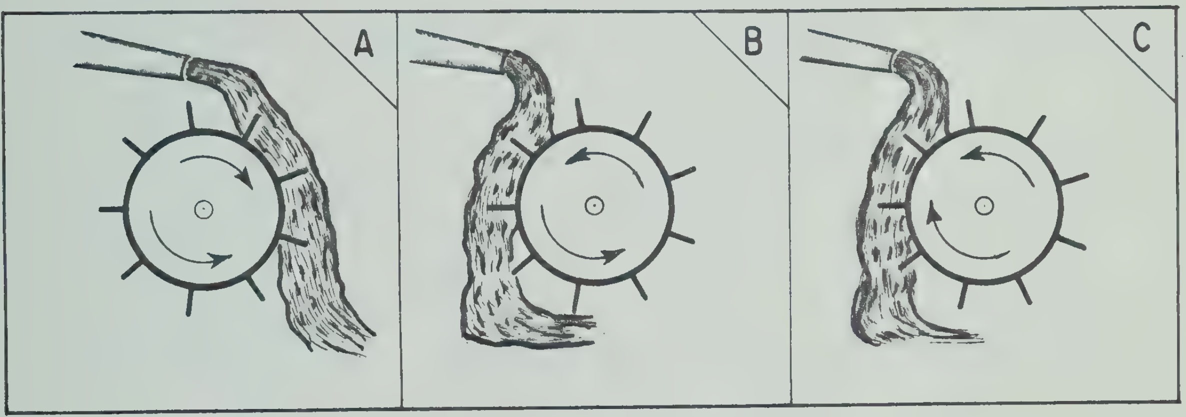
If you decide to change an answer, <u>be sure to erase the mark you do not want</u>, then mark the one you do want - USE PENCIL ONLY.

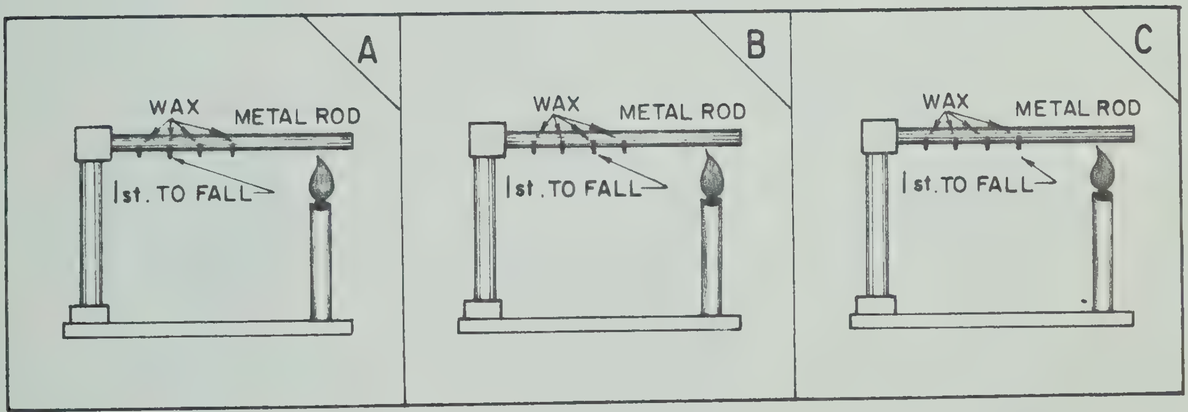
There are 40 illustrated science questions like the one in the sample. Look carefully at each frame and then choose the one correct answer. Mark your answers on the separate answer sheet. Do your best work but <u>do not spend too much time on any one question</u>. You will have thirty minutes to complete the test.

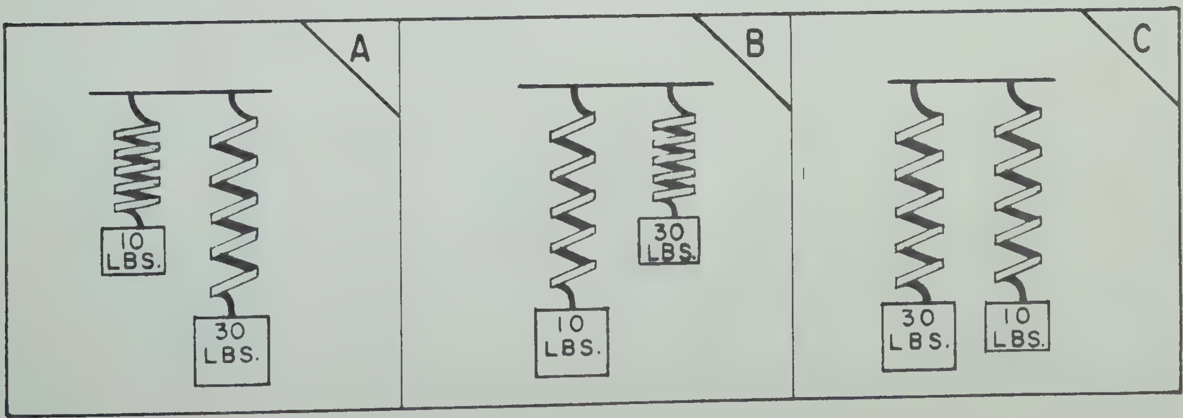
DO <u>NOT</u> OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

INDICATE YOUR ANSWER ON THE ANSWER SHEET
PLEASE DO NOT MARK ON THIS PAGE

1  1

2  2

3  3

4  4

INDICATE YOUR ANSWER ON THE ANSWER SHEET
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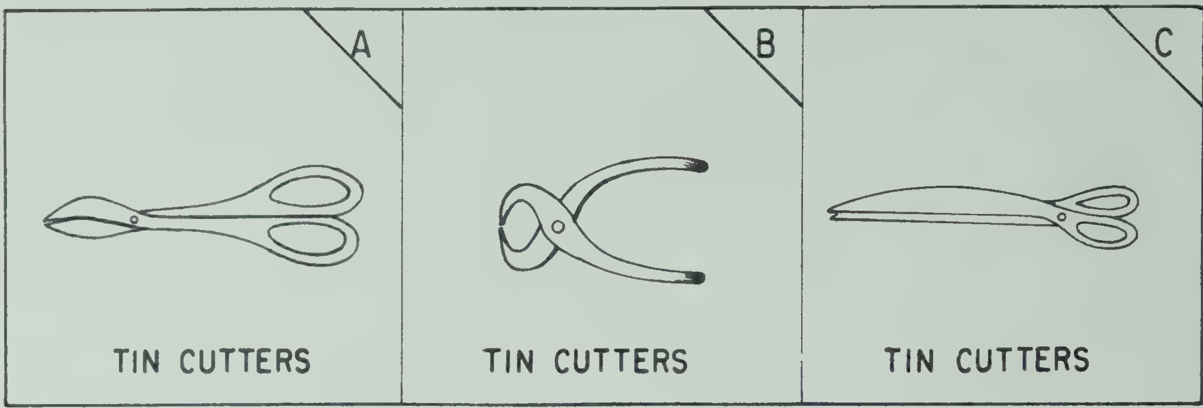

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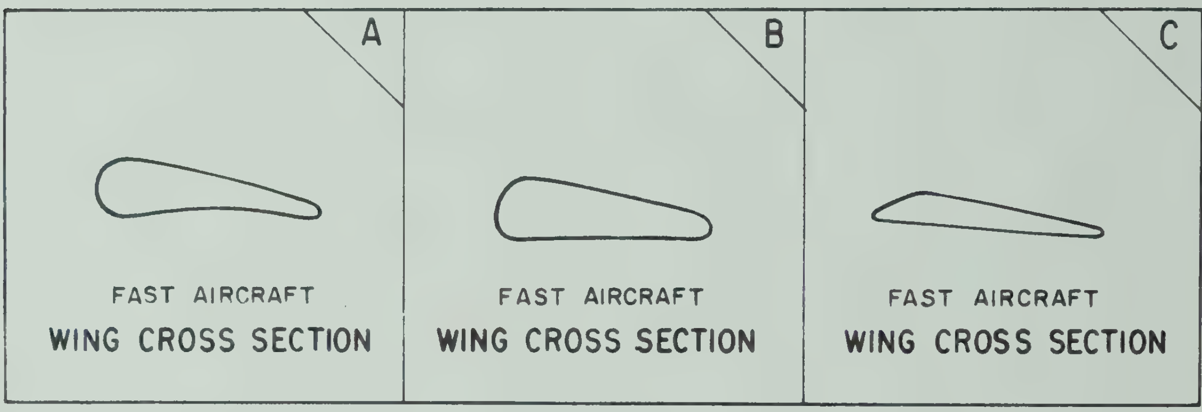

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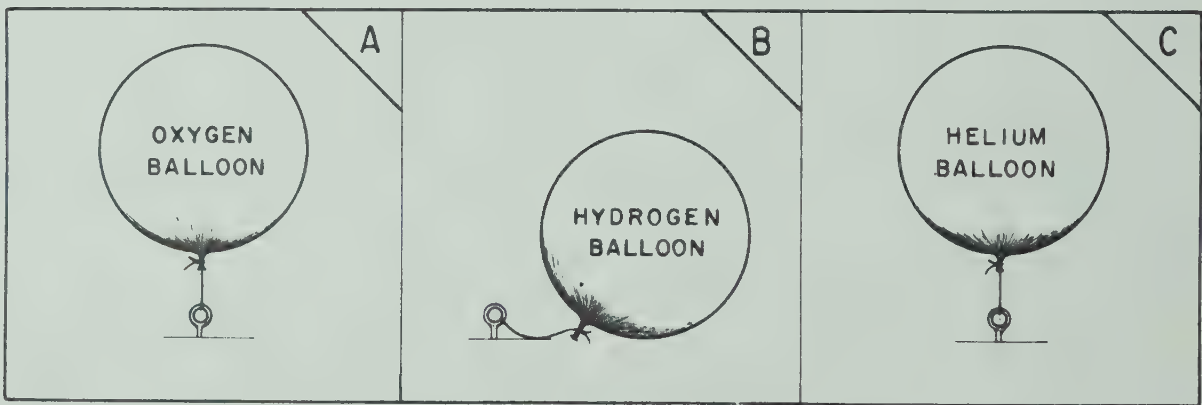

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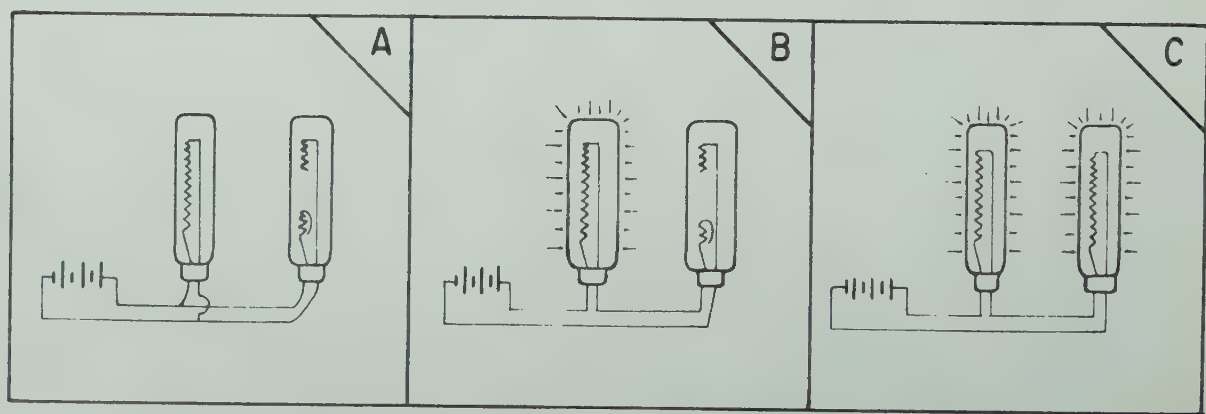

8

INDICATE YOUR ANSWER ON THE ANSWER SHEET
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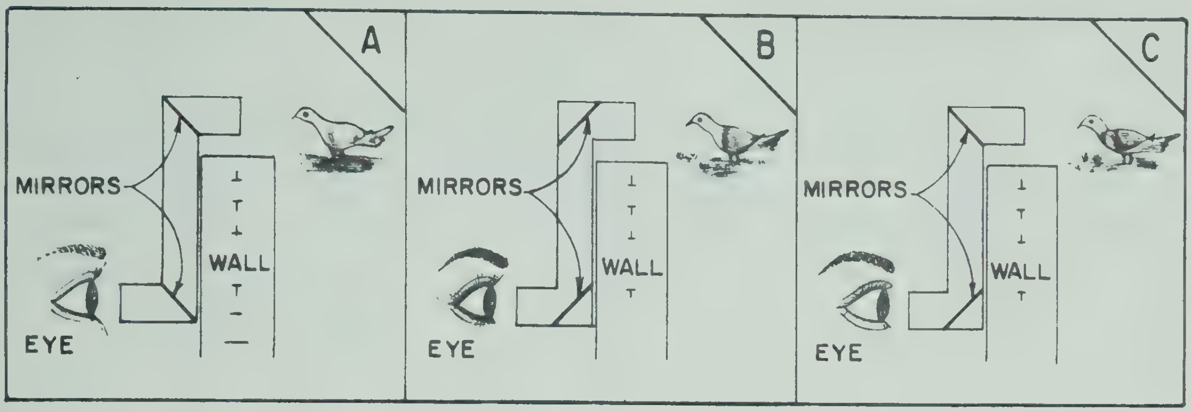

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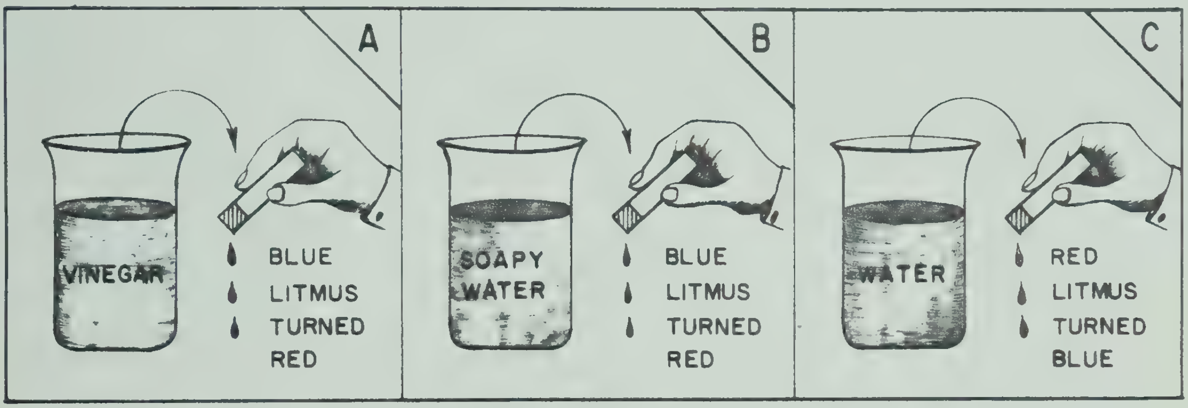

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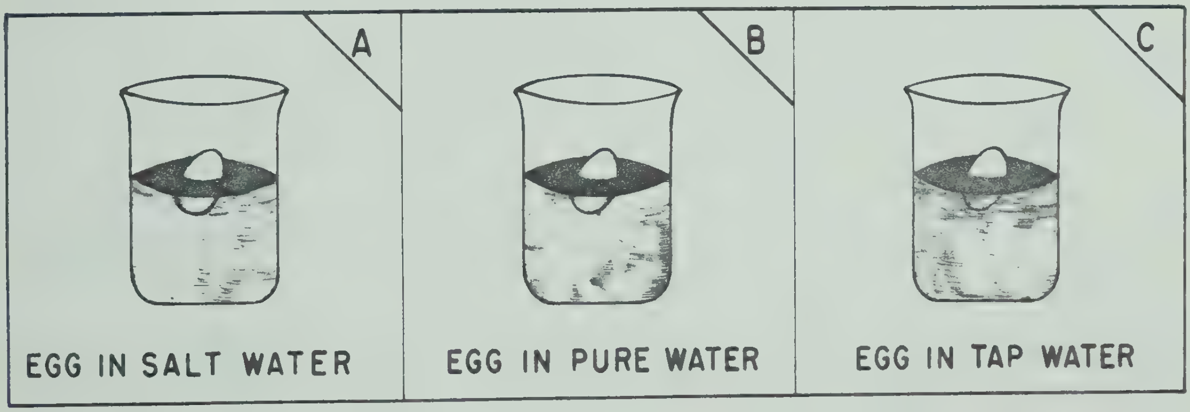

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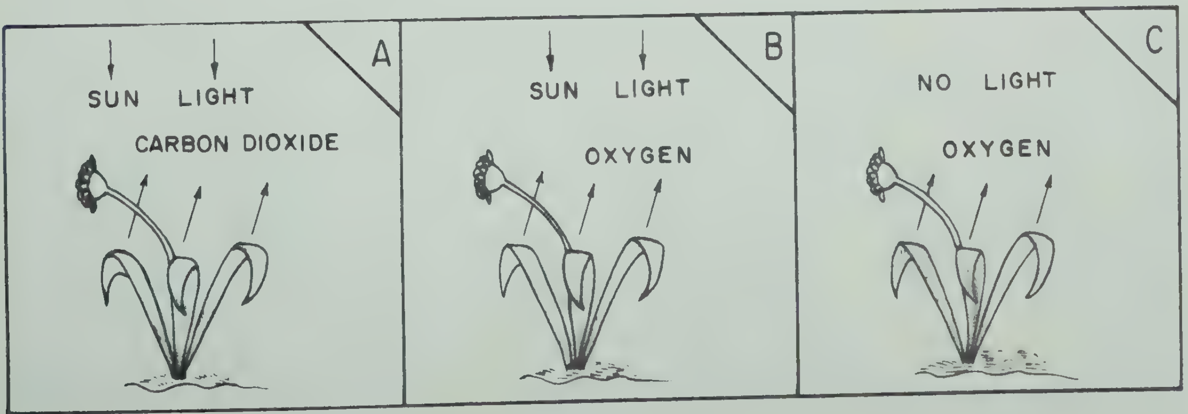

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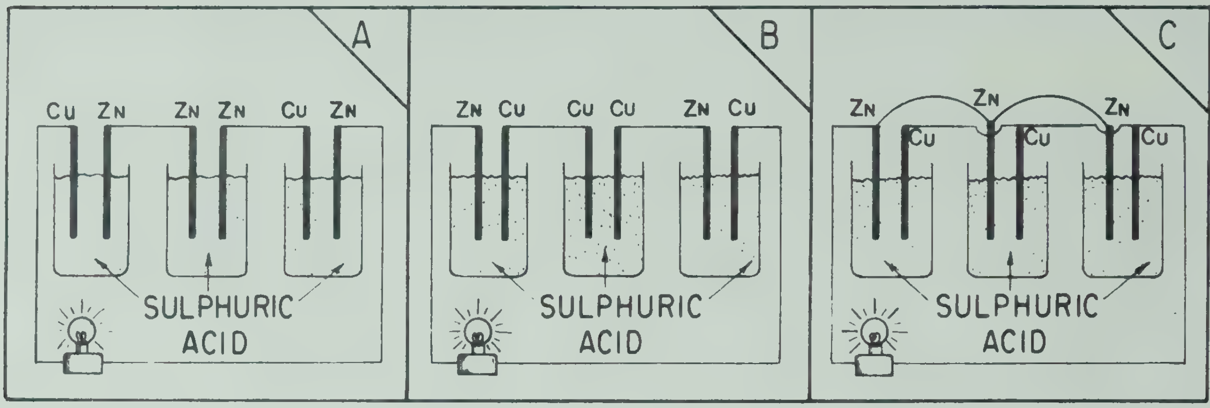

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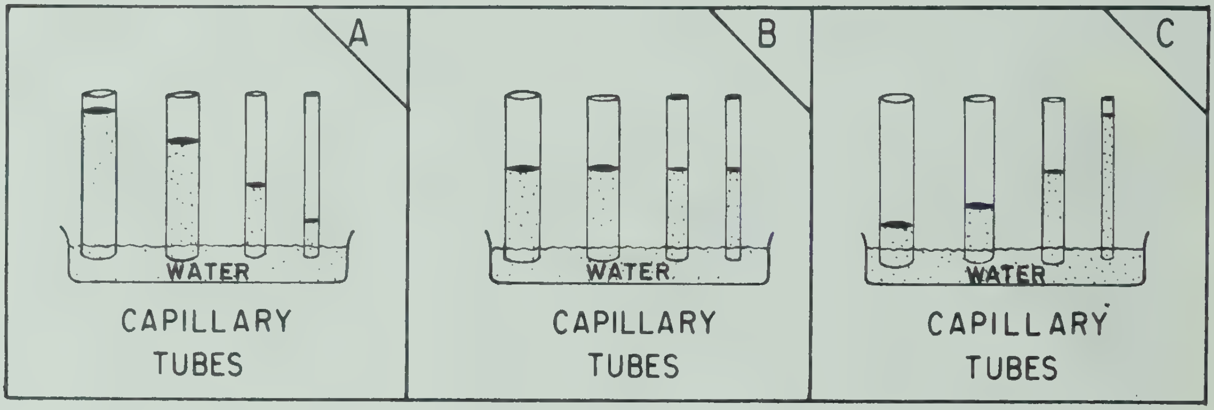

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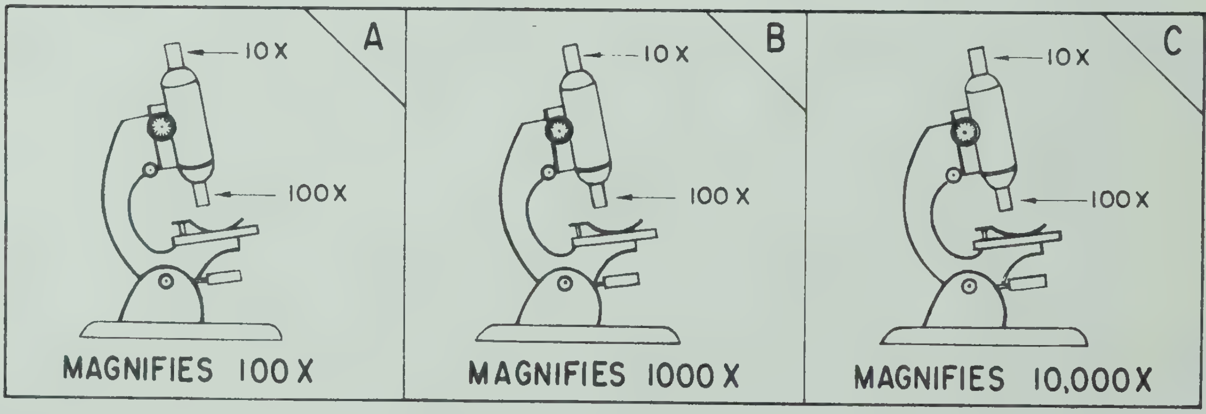

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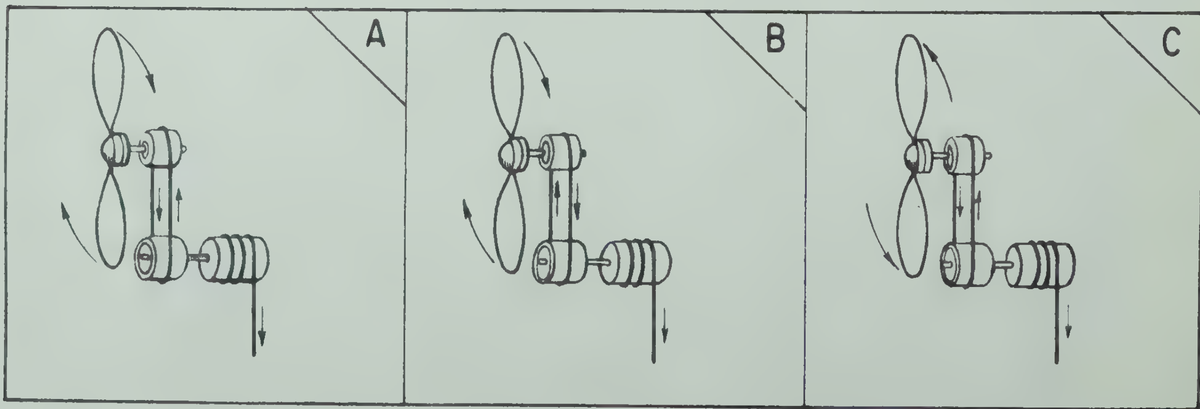

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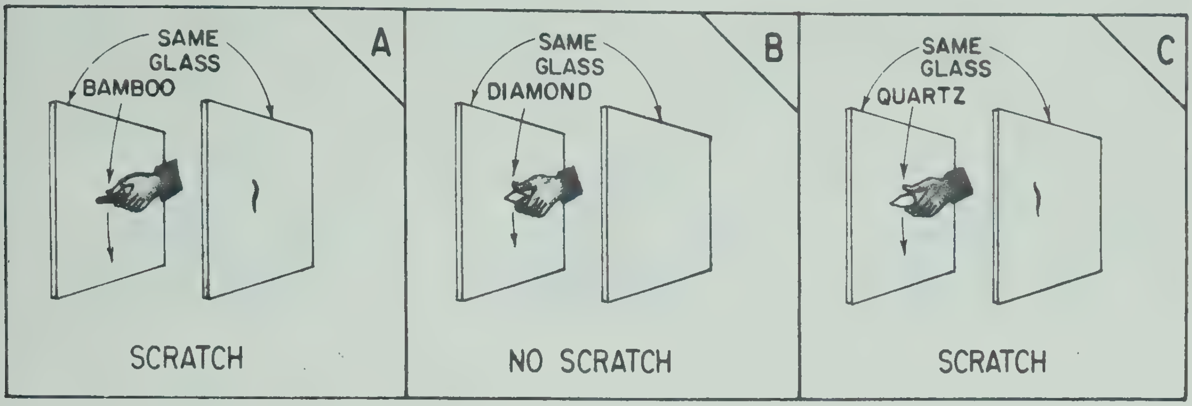

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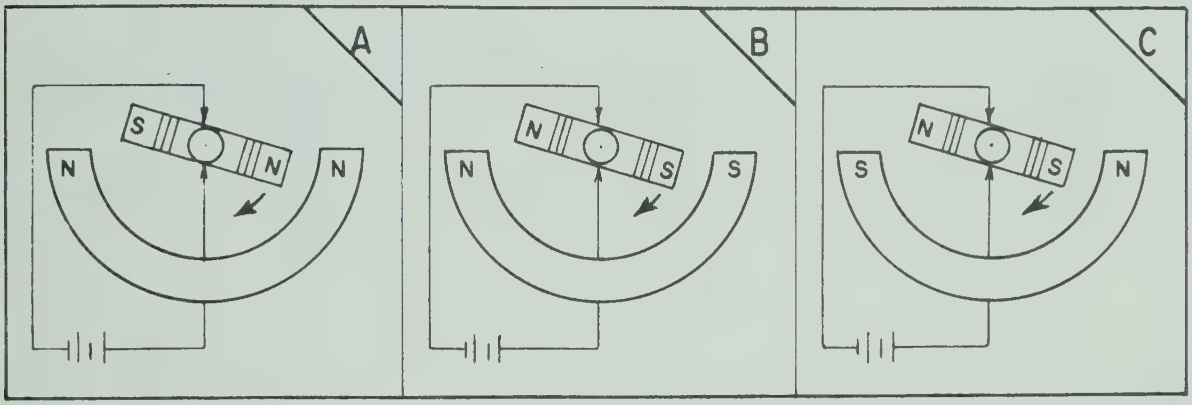

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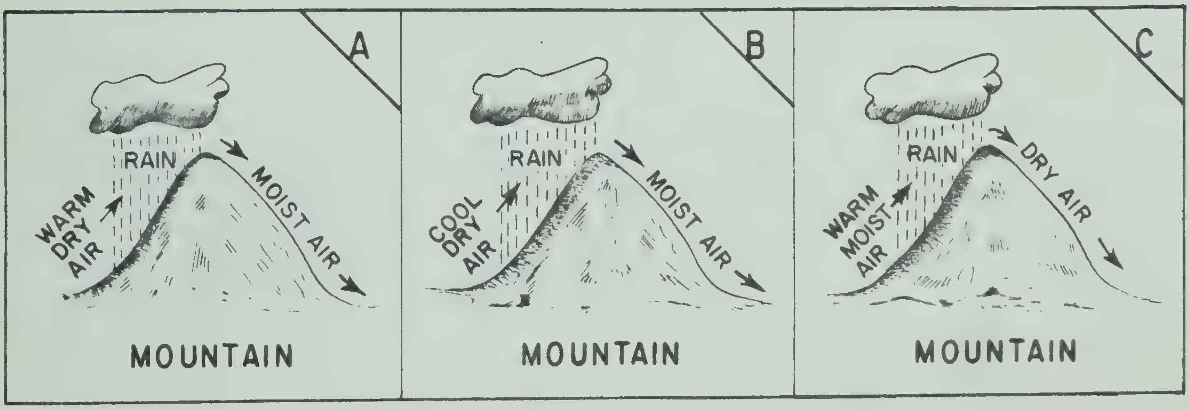

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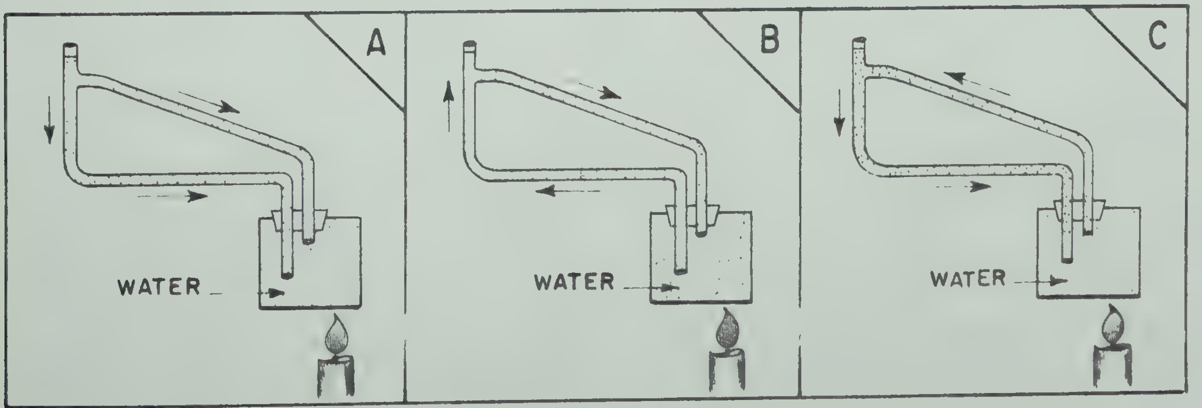

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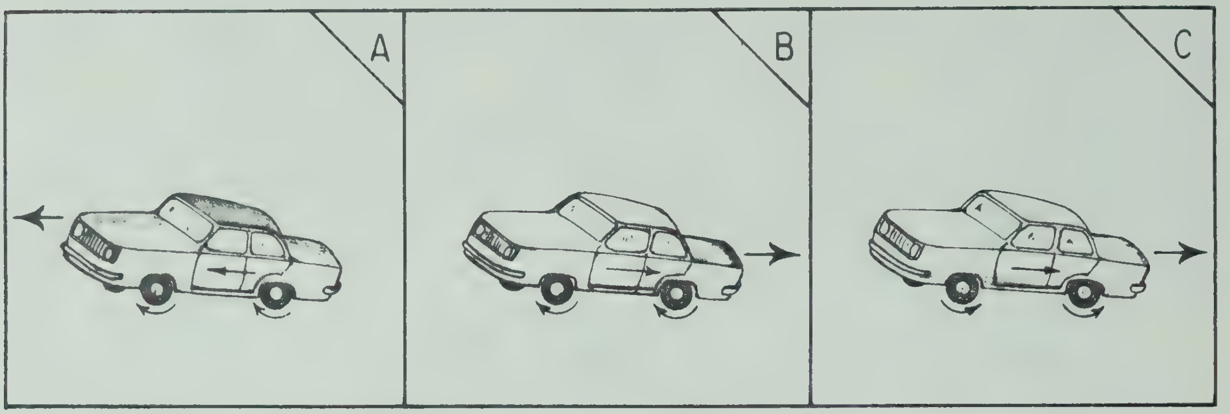

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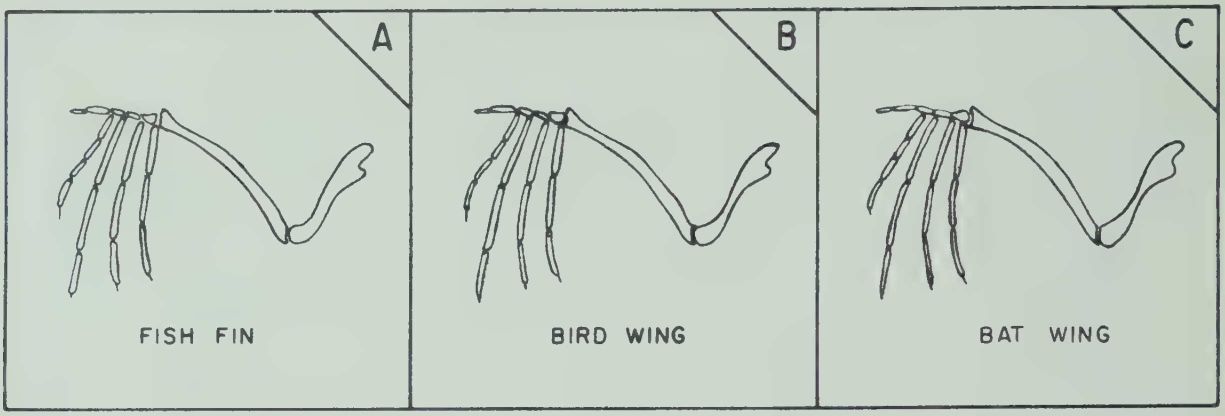

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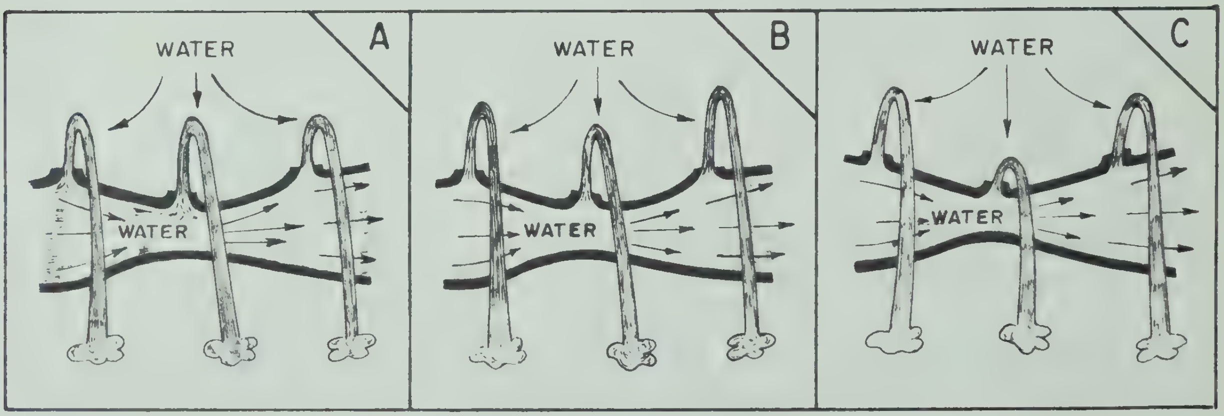

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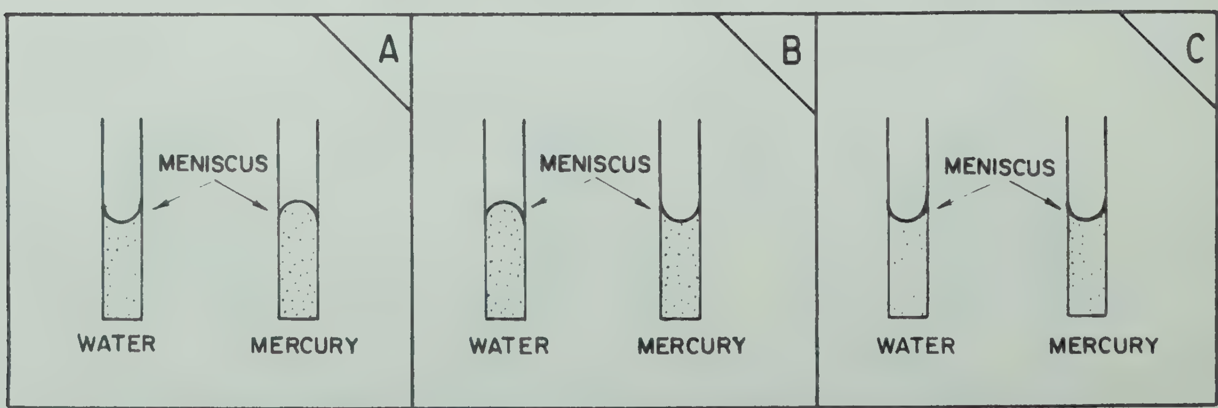

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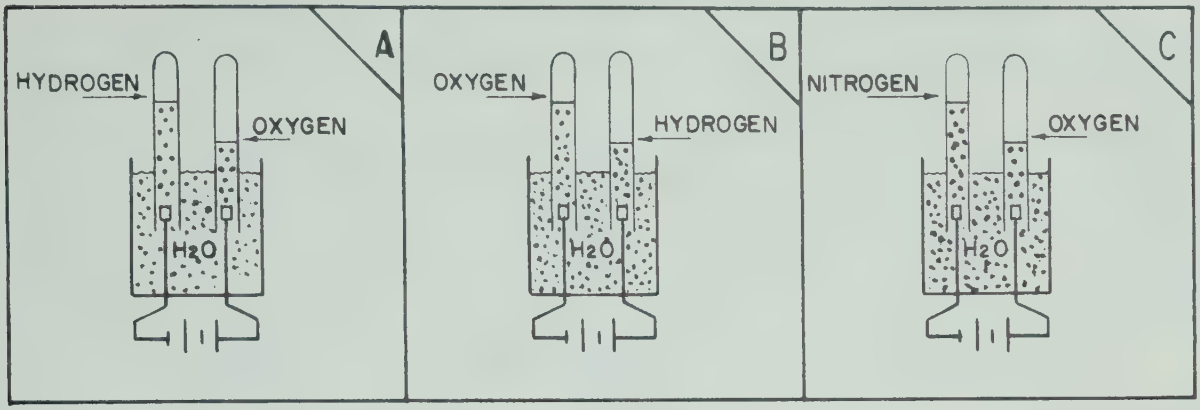

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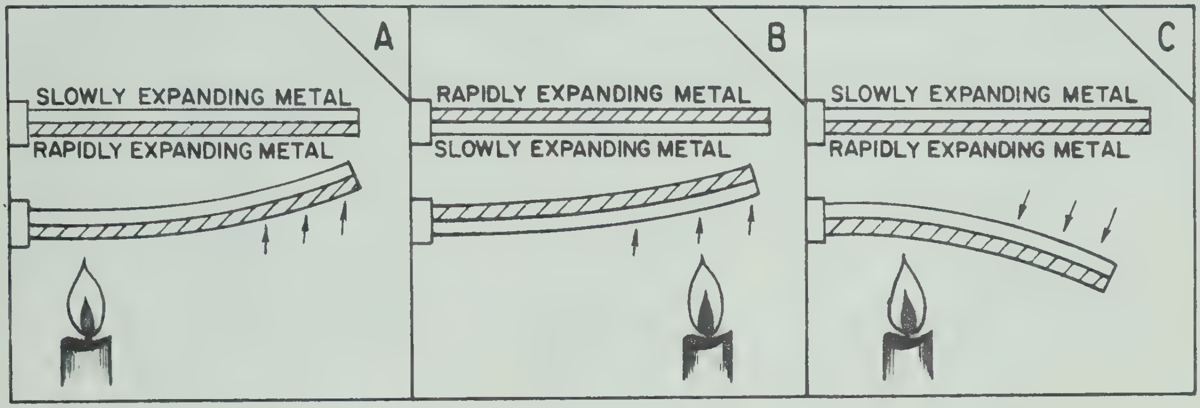

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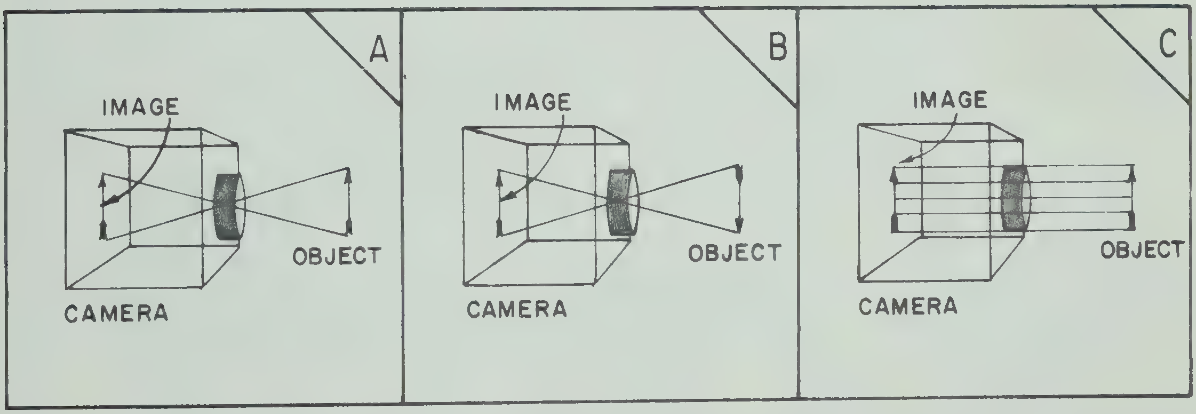

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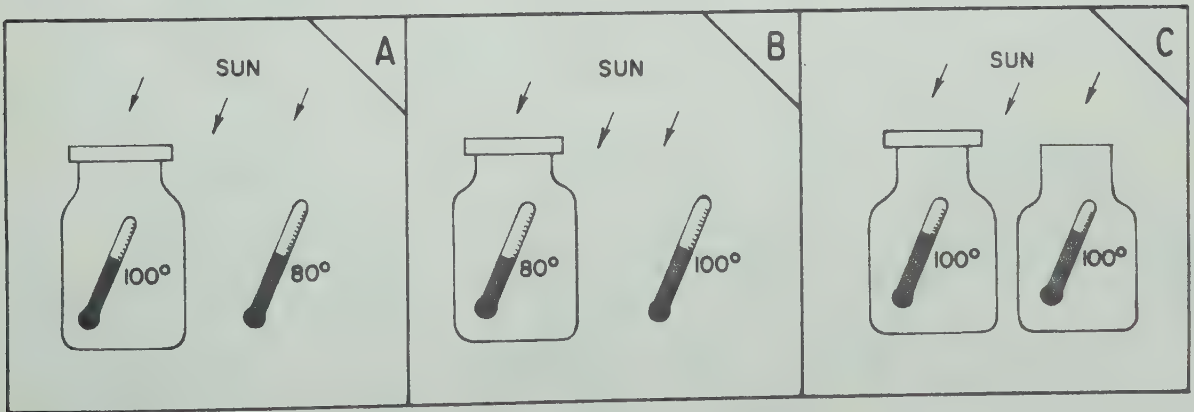

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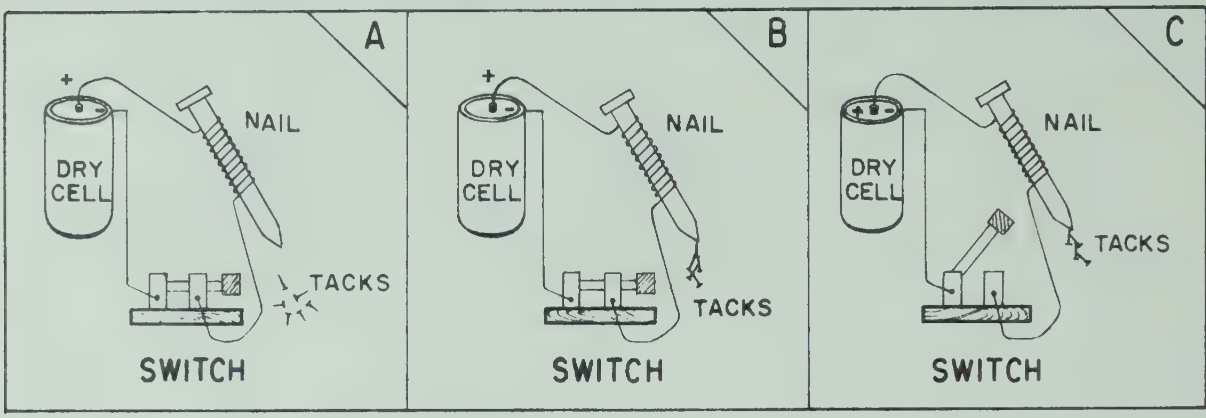

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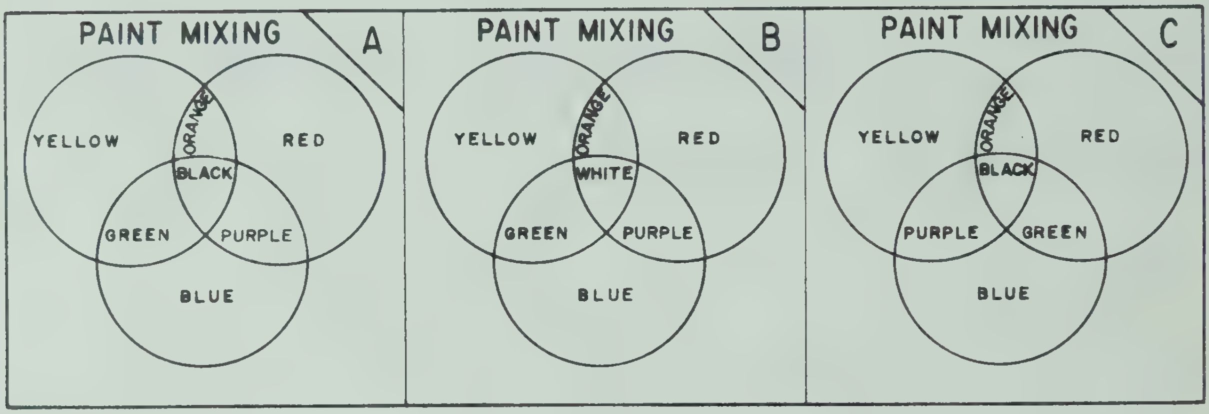

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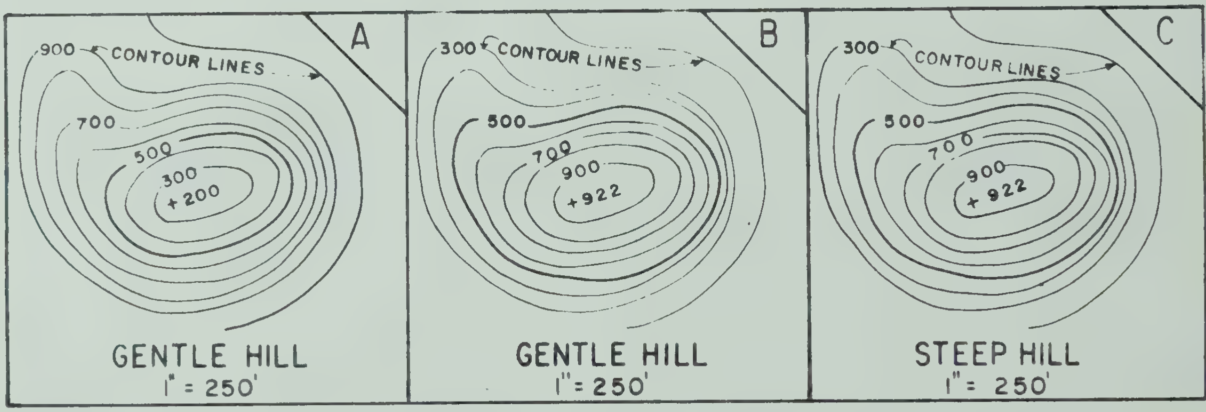

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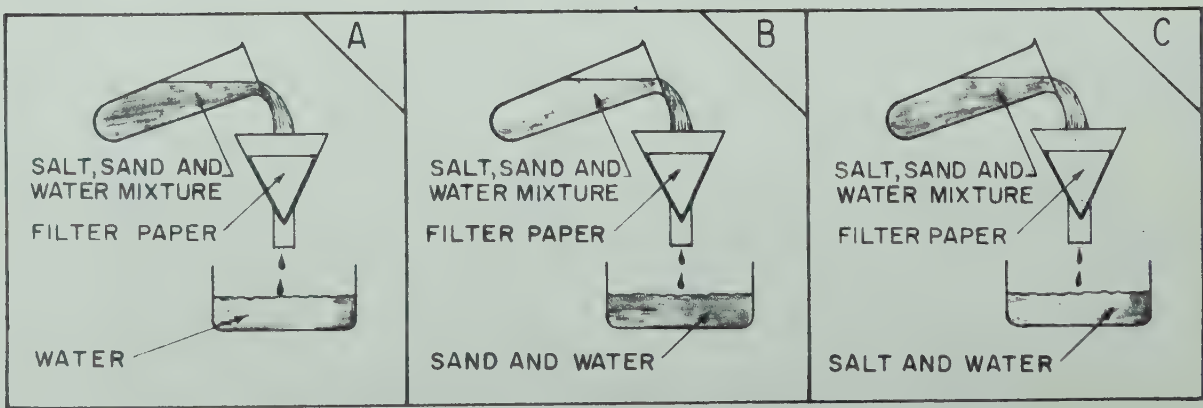

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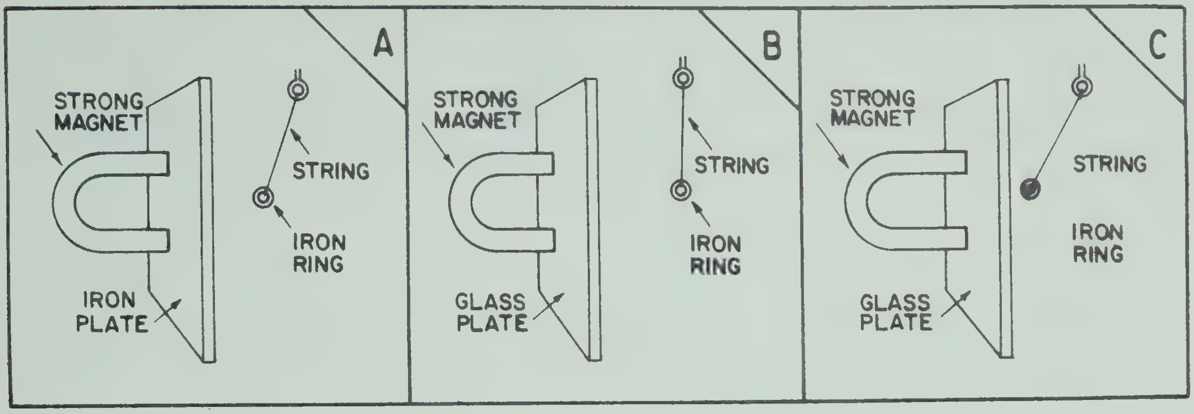

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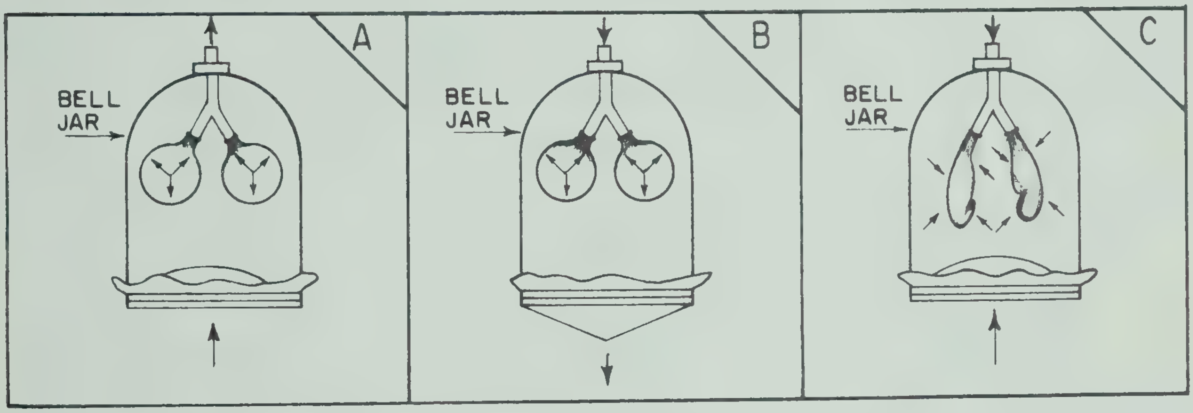

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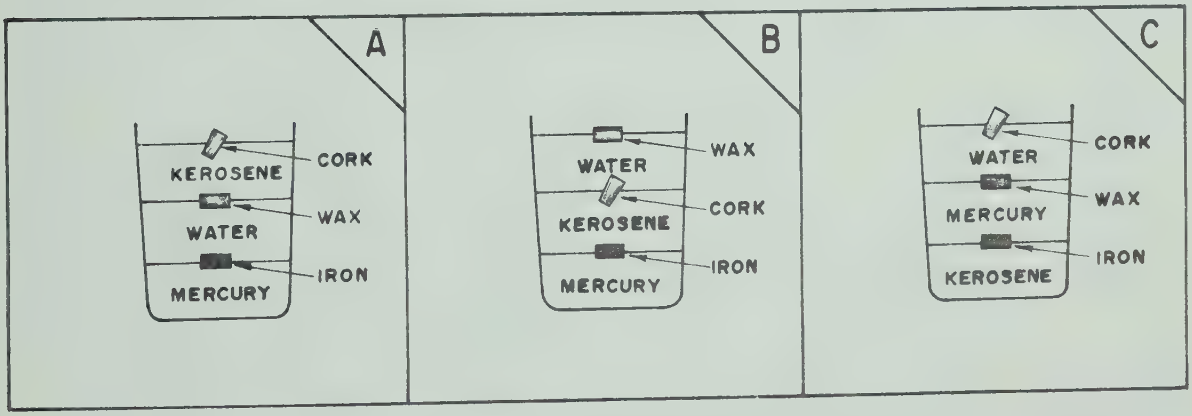

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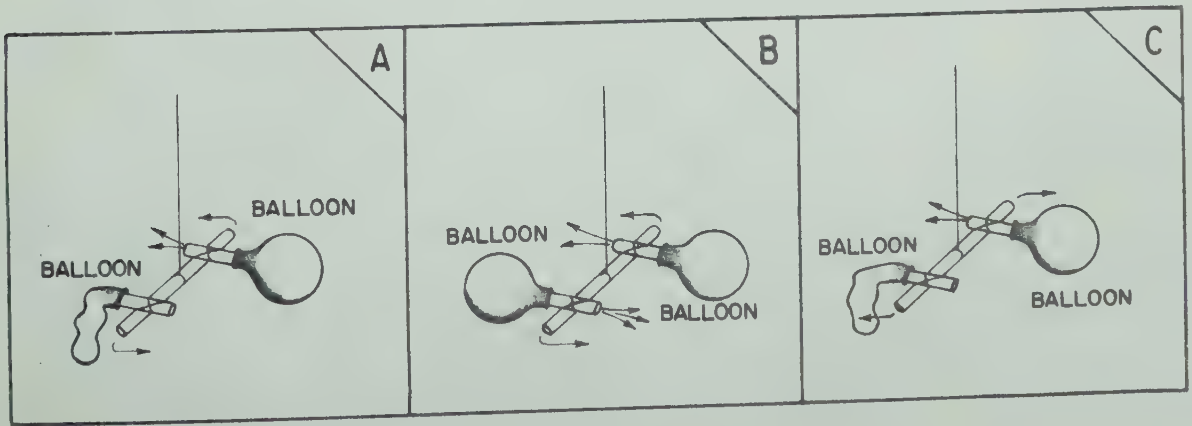

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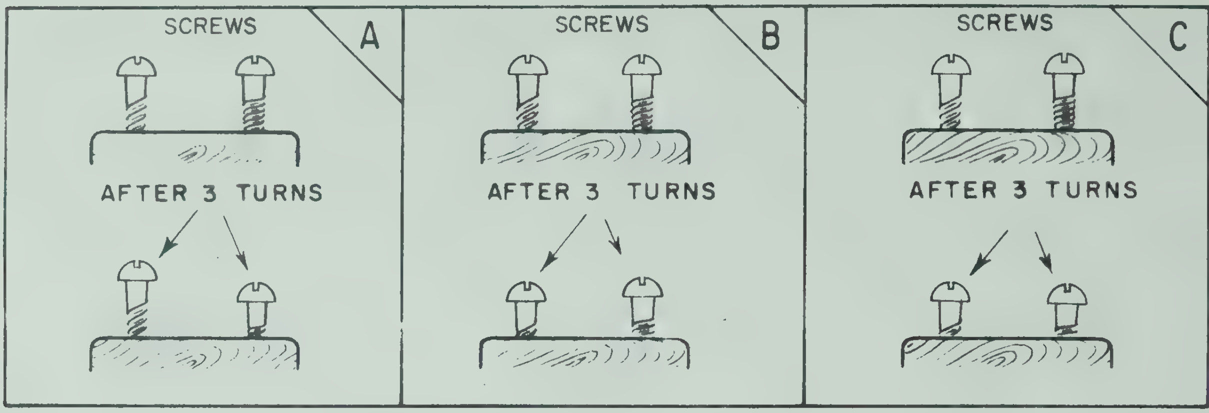

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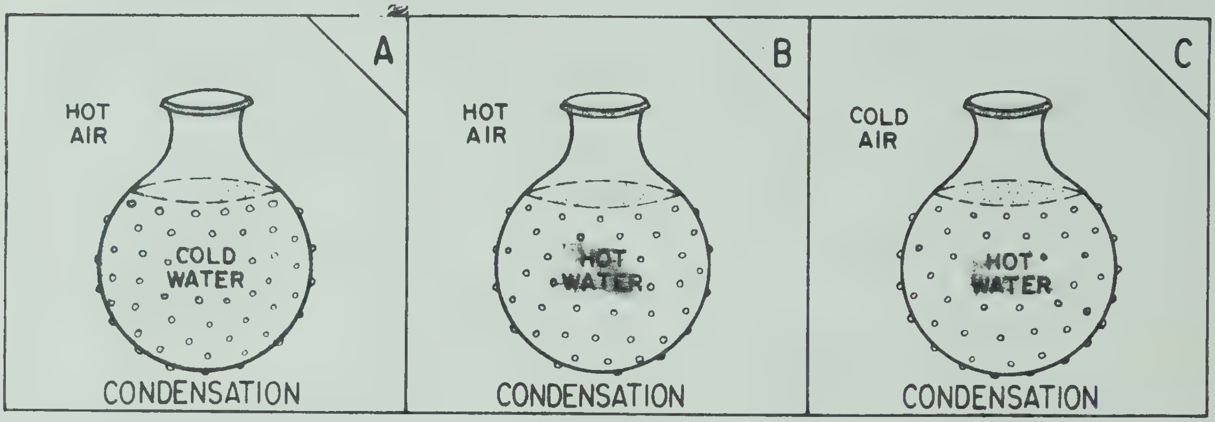

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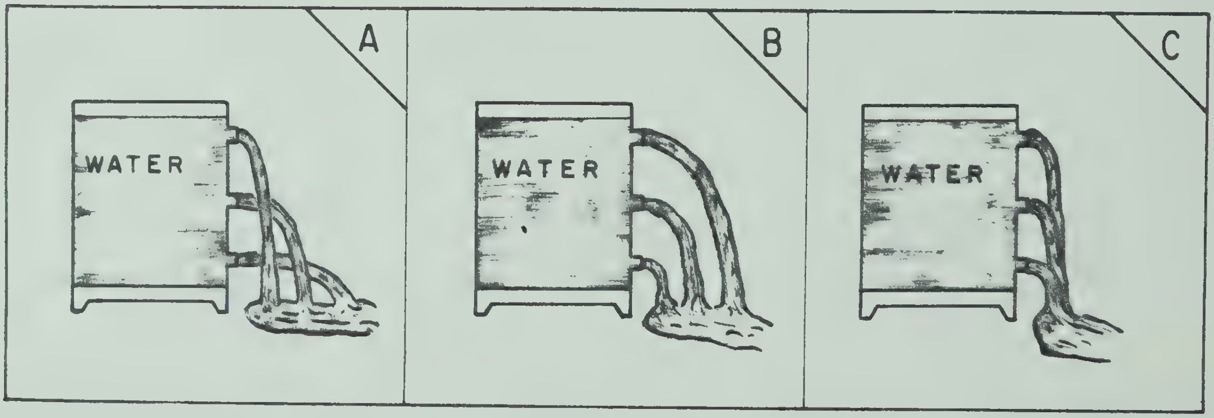

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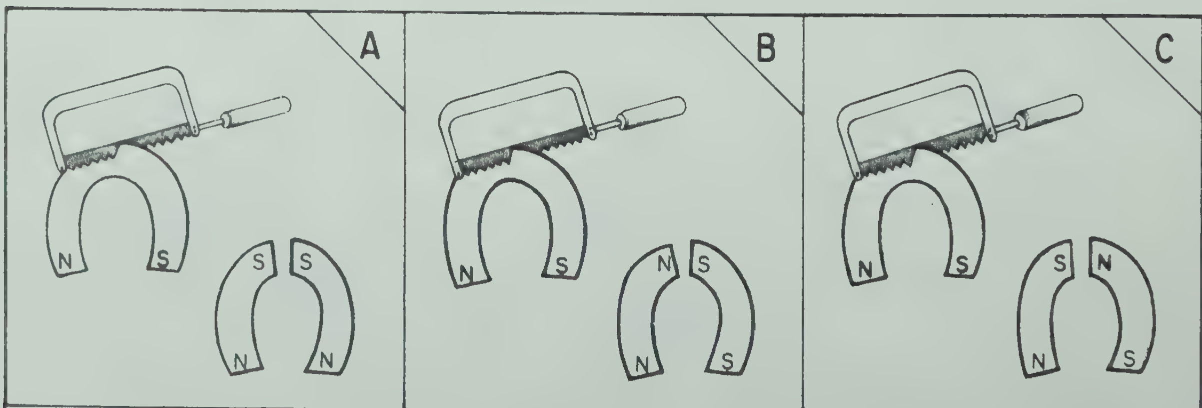

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